E

fx-9750GII

User's Guide

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RJA525156-001V01

GUIDELINES LAID DOWN BY FCC RULES FOR USE OF THE UNIT IN THE U.S.A. (not applicable to other areas).

NOTICE

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

FCC WARNING

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.
Proper connectors must be used for connection to host computer and/or peripherals in order to meet FCC emission limits.

Connector SB-62	Power Graphic Unit to Power Graphic Unit
Connector FA-124	Power Graphic Unit to Windows® compatible PC

Declaration of Conformity

Model Number:	fx-9750GII
Trade Name:	CASIO COMPUTER CO., LTD.
Responsible party:	CASIO AMERICA, INC.
Address:	570 MT. PLEASANT AVENUE, DOVER, NEW JERSEY 07801
Telephone number:	973-361-5400

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

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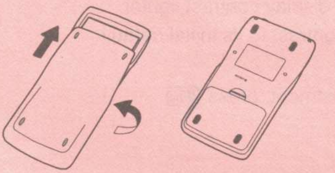
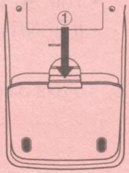
BEFORE USING THE CALCULATOR FOR THE FIRST TIME...

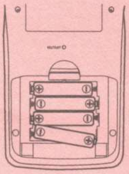
Batteries are not loaded in your calculator at the factory.
Be sure to follow the procedure below to load batteries and adjust the display contrast before trying to use the calculator for the first time.

1. Making sure that you do not accidently press the AC/ON key, slide the case onto the calculator and then turn the calculator over. Remove the battery cover from the calculator by pulling with your finger at the point marked ①.

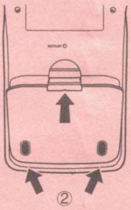




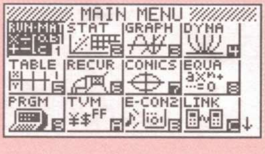
2. Load the four batteries that come with the calculator.
   - Make sure that the positive (+) and negative (–) ends of the batteries are facing correctly.

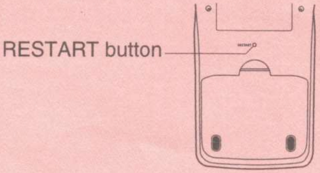


3. Replace the battery cover, making sure that its tabs enter the holes marked ② and turn the calculator front side up. The calculator will turn on automatically and the MAIN MENU will appear on the display.

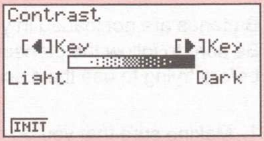


- If the Main Menu shown to the right is not on the display, press the RESTART button on the back of the calculator.





4. Use the cursor keys (▲, ▼, ◀, ▶) to select the **SYSTEM** icon and press [EXE], then press [F1] (◧) to display the contrast adjustment screen.



Contrast

[◀]Key [▶]Key

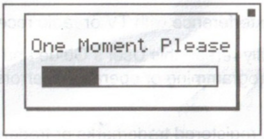
Light Dark

5. Adjust the contrast.
   - The ▶ cursor key makes display contrast darker.
   - The ◀ cursor key makes display contrast lighter.
   - [F1](INIT) returns display contrast to its initial default.

6. To exit display contrast adjustment, press [MENU].

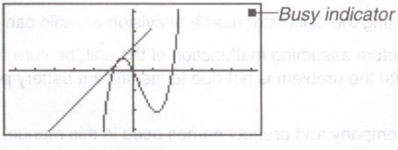
Precautions when Using this Product

A progress bar and/or a busy indicator appear on the display whenever the calculator is performing a calculation, writing to memory, or reading from memory.



One Moment Please

Progress bar



Never press the RESTART button or remove the batteries from the calculator when the progress bar or busy indicator is on the display. Doing so can cause memory contents to be lost and can cause malfunction of the calculator.

Handling Precautions

- Your calculator is made up of precision components. Never try to take it apart.
- Avoid dropping your calculator and subjecting it to strong impact.
- Do not store the calculator or leave it in areas exposed to high temperatures or humidity, or large amounts of dust. When exposed to low temperatures, the calculator may require more time to display results and may even fail to operate. Correct operation will resume once the calculator is brought back to normal temperature.
- The display will go blank and keys will not operate during calculations. When you are operating the keyboard, be sure to watch the display to make sure that all your key operations are being performed correctly.
- Replace the main batteries once every one year regardless of how much the calculator is used during that period.. Never leave dead batteries in the battery compartment. They can leak and damage the unit.
- Do not use an oxyride battery* or any other type of nickel-based primary battery with this product. Incompatibility between such batteries and product specifications can result in shorter battery life and product malfunction.
- Keep batteries out of the reach of small children. If swallowed, consult a physician immediately.
- Avoid using volatile liquids such as thinner or benzine to clean the unit. Wipe it with a soft, dry cloth, or with a cloth that has been moistened with a solution of water and a neutral detergent and wrung out.
- Always be gentle when wiping dust off the display to avoid scratching it.
- In no event will the manufacturer and its suppliers be liable to you or any other person for any damages, expenses, lost profits, lost savings or any other damages arising out of loss of data and/or formulas arising out of malfunction, repairs, or battery replacement. It is up to you to prepare physical records of data to protect against such data loss.
- Never dispose of batteries, the liquid crystal panel, or other components by burning them.
- Be sure that the power switch is set to OFF when replacing batteries.
- If the calculator is exposed to a strong electrostatic charge, its memory contents may be damaged or the keys may stop working. In such a case, perform the Reset operation to clear the memory and restore normal key operation.

- If the calculator stops operating correctly for some reason, use a thin, pointed object to press the RESTART button on the back of the calculator. Note, however, that this clears all the data in calculator memory.
- Note that strong vibration or impact during program execution can cause execution to stop or can damage the calculator's memory contents.
- Using the calculator near a television or radio can cause interference with TV or radio reception.
- Before assuming malfunction of the unit, be sure to carefully reread this User's Guide and ensure that the problem is not due to insufficient battery power, programming or operational errors.

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Be sure to keep physical records of all important data!

The large memory capacity of the unit makes it possible to store large amounts of data.

You should note, however, that low battery power or incorrect replacement of the batteries that power the unit can cause the data stored in memory to be corrupted or even lost entirely. Stored data can also be affected by strong electrostatic charge or strong impact. It is up to you to keep back up copies of data to protect against its loss.

Since this calculator employs unused memory as a work area when performing its internal calculations, an error may occur when there is not enough memory available to perform calculations. To avoid such problems, it is a good idea to leave 1 or 2 kbytes of memory free (unused) at all times.

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- The contents of this User's Guide are subject to change without notice.
- No part of this User's Guide may be reproduced in any form without the express written consent of the manufacturer.
- The options described in Chapter 11 of this User's Guide may not be available in certain geographic areas. For full details on availability in your area, contact your nearest CASIO dealer or distributor.
- Be sure to keep all user documentation handy for future reference.

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Getting Acquainted — Read This First!

About this User's Guide

• SHIFT x^2(√)

The above indicates you should press SHIFT and then x^2, which will input a √ symbol. All multiple-key input operations are indicated like this. Key cap markings are shown, followed by the input character or command in parentheses.

• MENU EQUA

This indicates you should first press MENU, use the cursor keys (▲, ▼, ◀, ▶) to select the **EQUA** mode, and then press EXE. Operations you need to perform to enter a mode from the Main Menu are indicated like this.

• Function Keys and Menus

- Many of the operations performed by this calculator can be executed by pressing function keys F1 through F6. The operation assigned to each function key changes according to the mode the calculator is in, and current operation assignments are indicated by function menus that appear at the bottom of the display.
- This User's Guide shows the current operation assigned to a function key in parentheses following the key cap for that key. F1(Comp), for example, indicates that pressing F1 selects {Comp}, which is also indicated in the function menu.
- When (▷) is indicated in the function menu for key F6, it means that pressing F6 displays the next page or previous page of menu options.

• Menu Titles

- Menu titles in this User's Guide include the key operation required to display the menu being explained. The key operation for a menu that is displayed by pressing OPTN and then {LIST} would be shown as: **[OPTN]**-**[LIST]**.
- F6(▷) key operations to change to another menu page are not shown in menu title key operations.

• Command List

The **PRGM** Mode Command List (page 8-37) provides a graphic flowchart of the various function key menus and shows how to maneuver to the menu of commands you need.

Example: The following operation displays Xfct: **[VARS]**-**[FACT]**-**[Xfct]**

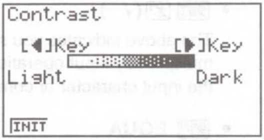
• E-CON2

This manual does not cover the **E-CON2** mode. For more information about the **E-CON2** mode, download the E-CON2 manual (English version only) from: http://edu.casio.com.

■ Contrast Adjustment

Adjust the contrast whenever objects on the display appear dim or difficult to see.

1. Use the cursor keys (▲, ▼, ◀, ▶) to select the **SYSTEM** icon and press EXE, then press F1(◐) to display the contrast adjustment screen.



Contrast

[◀]Key [▶]Key

Light Dark

2. Adjust the contrast.
   - The ▶ cursor key makes display contrast darker.
   - The ◀ cursor key makes display contrast lighter.
   - F1(INIT) returns display contrast to its initial default.
3. To exit display contrast adjustment, press MENU.

Chapter 1 Basic Operation

1. Keys

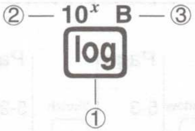
■ Key Table

Key	Page	Key	Page	Key	Page	Key	Page	Key	Page	Key	Page
Trace F1	5-30	Zoom F2	5-5	V-Window F3	5-3	Sketch F4	5-27	G-Solv F5	5-30	G↔T F6	5-1 5-23
SHIFT	1-2	OPTN	1-9	PRGM VARS	1-13 1-10	SET UP MENU	1-14 1-2	△ ◁ REPLAY ▷ ▽			
A-LOCK ALPHA	2-5 1-2	√ r x^2	2-12 2-12	$\sqrt[x]{}$ θ ^	2-11 2-11	QUIT EXIT					
∠ A X,θ,T	2-27	10^x B log	2-11	e^x C ln		$\sin^{-1}$ D sin	2-11 2-11	$\cos^{-1}$ E cos	2-11	$\tan^{-1}$ F tan	
G a b/c	2-16	$a\frac{b}{c} \leftrightarrow \frac{d}{c}$ H F↔D	2-16 2-16	$\sqrt[3]{}$ I (	2-1	x^{-1} J)	2-1	K ,		L →	2-4

Key	Page	Key	Page	Key	Page	Key	Page	Key	Page
CAPTURE M 7	1-17	CLIP N 8	1-8	PASTE O 9	1-8	INS DEL	1-5 1-6	OFF AC/ON	
CATALOG P 4	1-9	Q 5		R 6		{ S ×	2-1	} T ÷	2-1
List U 1	3-2	Mat V 2	2-38	W 3		[X +	2-1	] Y −	2-1
i Z 0	2-27	= SPACE .		π ” EXP	2-11 2-5 2-1	Ans (−)	2-7 2-1	↵ EXE	

Key Markings

Many of the calculator's keys are used to perform more than one function. The functions marked on the keyboard are color coded to help you find the one you need quickly and easily.



	Function	Key Operation
①	log	log
②	10^x	SHIFT log
③	B	ALPHA log

The following describes the color coding used for key markings.

Color	Key Operation
Yellow	Press SHIFT and then the key to perform the marked function.
Red	Press ALPHA and then the key to perform the marked function.

- A-LOCK ALPHA **Alpha Lock**

  Normally, once you press ALPHA and then a key to input an alphabetic character, the keyboard reverts to its primary functions immediately.
  If you press SHIFT and then ALPHA, the keyboard locks in alpha input until you press ALPHA again.

2. Display

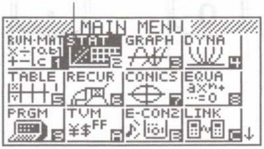
Selecting Icons

This section describes how to select an icon in the Main Menu to enter the mode you want.

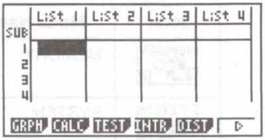
• To select an icon

1. Press MENU to display the Main Menu.
2. Use the cursor keys (◀, ▶, ▲, ▼) to move the highlighting to the icon you want.

Currently selected icon



3. Press EXE to display the initial screen of the mode whose icon you selected. Here we will enter the **STAT** mode.



- You can also enter a mode without highlighting an icon in the Main Menu by inputting the number or letter marked in the lower right corner of the icon.
- Use only the procedures described above to enter a mode. If you use any other procedure, you may end up in a mode that is different than the one you thought you selected.

The following explains the meaning of each icon.

Icon	Mode Name	Description
RUN·MAT 1	RUN • MAT (Run • Matrix)	Use this mode for arithmetic calculations and function calculations, and for calculations involving binary, octal, decimal, and hexadecimal values and matrices.
STAT 2	STAT (Statistics)	Use this mode to perform single-variable (standard deviation) and paired-variable (regression) statistical calculations, to perform tests, to analyze data and to draw statistical graphs.
GRAPH 3	GRAPH	Use this mode to store graph functions and to draw graphs using the functions.
DYNA 4	DYNA (Dynamic Graph)	Use this mode to store graph functions and to draw multiple versions of a graph by changing the values assigned to the variables in a function.
TABLE 5	TABLE	Use this mode to store functions, to generate a numeric table of different solutions as the values assigned to variables in a function change, and to draw graphs.
RECUR 6	RECUR (Recursion)	Use this mode to store recursion formulas, to generate a numeric table of different solutions as the values assigned to variables in a function change, and to draw graphs.
CONICS 7	CONICS	Use this mode to draw graphs of conic sections.
EQUA 8	EQUA (Equation)	Use this mode to solve linear equations with two through six unknowns, and high-order equations from 2nd to 6th degree.
PRGM 9	PRGM (Program)	Use this mode to store programs in the program area and to run programs.
TVM A	TVM (Financial)	Use this mode to perform financial calculations and to draw cash flow and other types of graphs.
E-CON2 B	E-CON2	Use this mode to control the optionally available EA-200 Data Analyzer. For more information about the **E-CON2** mode, download the E-CON2 manual (English version only) from: http://edu.casio.com.
LINK C	LINK	Use this mode to transfer memory contents or back-up data to another unit or PC.

Icon	Mode Name	Description
MEMORY	MEMORY	Use this mode to manage data stored in memory.
SYSTEM	SYSTEM	Use this mode to initialize memory, adjust contrast, and to make other system settings.

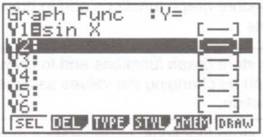
■ About the Function Menu

Use the function keys (F1 to F6) to access the menus and commands in the menu bar along the bottom of the display screen. You can tell whether a menu bar item is a menu or a command by its appearance.

■ About Display Screens

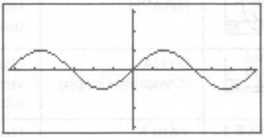
This calculator uses two types of display screens: a text screen and a graph screen. The text screen can show 21 columns and 8 lines of characters, with the bottom line used for the function key menu. The graph screen uses an area that measures 127 (W) × 63 (H) dots.

Text Screen



```
Graph Func  :Y=
Y1■sin X      [—]
Y2:           [—]
Y3:           [—]
Y4:           [—]
Y5:           [—]
Y6:           [—]
```

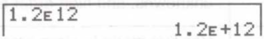
Graph Screen



■ Normal Display

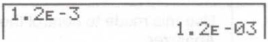
The calculator normally displays values up to 10 digits long. Values that exceed this limit are automatically converted to and displayed in exponential format.

• How to interpret exponential format



```
1.2E12
                1.2E+12
```

1.2E+12 indicates that the result is equivalent to 1.2 × 10^{12}. This means that you should move the decimal point in 1.2 twelve places to the right, because the exponent is positive. This results in the value 1,200,000,000,000.



```
1.2E-3
                1.2E-03
```

1.2E–03 indicates that the result is equivalent to 1.2 × 10^{-3}. This means that you should move the decimal point in 1.2 three places to the left, because the exponent is negative. This results in the value 0.0012.

You can specify one of two different ranges for automatic changeover to normal display.

Norm 1 .... 10^{-2} (0.01) > $|x|$, $|x| \geqq 10^{10}$

Norm 2 .... 10^{-9} (0.000000001) > $|x|$, $|x| \geqq 10^{10}$

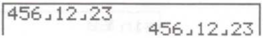
All of the examples in this manual show calculation results using Norm 1.

See page 2-8 for details on switching between Norm 1 and Norm 2.

■ Special Display Formats

This calculator uses special display formats to indicate fractions, hexadecimal values, and degrees/minutes/seconds values.

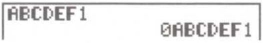
- Fractions



```
456⌟12⌟23
                456⌟12⌟23
```

.... Indicates: $456\frac{12}{23}$

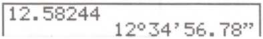
- Hexadecimal Values



```
ABCDEF1
                 0ABCDEF1
```

.... Indicates: $0ABCDEF1_{(16)}$, which equals $180150001_{(10)}$

- Degrees/Minutes/Seconds



```
12.58244
             12°34'56.78"
```

.... Indicates: 12° 34' 56.78"

- In addition to the above, this calculator also uses other indicators or symbols, which are described in each applicable section of this manual as they come up.

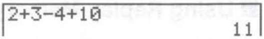
3. Inputting and Editing Calculations

■ Inputting Calculations

When you are ready to input a calculation, first press AC to clear the display. Next, input your calculation formulas exactly as they are written, from left to right, and press EXE to obtain the result.

Example **2 + 3 – 4 + 10 =**

AC 2 + 3 − 4 + 1 0 EXE



```
2+3-4+10
                       11
```

■ Editing Calculations

Use the ◀ and ▶ keys to move the cursor to the position you want to change, and then perform one of the operations described below. After you edit the calculation, you can execute it by pressing EXE. Or you can use ▶ to move to the end of the calculation and input more.

- You can select either insert or overwrite for input. With overwrite, text you input replaces the text at the current cursor location. You can toggle between insert and overwrite by performing the operation: SHIFT DEL(INS). The cursor appears as "▮" for insert and as "▬" for overwrite.

• To change a step

Example **To change cos60 to sin60**

[AC] [cos] [6] [0]

```
cos 60▮
```

◀ ◀ ◀

```
▮cos 60
```

[DEL]

```
▮60
```

[sin]

```
sin ▮60
```

• To delete a step

Example **To change 369 × × 2 to 369 × 2**

[AC] [3] [6] [9] [×] [×] [2]

```
369××2▮
```

◀ [DEL]

```
369×▮2
```

In the insert mode, the [DEL] key operates as a backspace key.

• To insert a step

Example **To change 2.36^2 to $\sin 2.36^2$**

[AC] [2] [•] [3] [6] [x^2]

```
2.36²▮
```

◀ ◀ ◀ ◀ ◀

```
▮.36²
```

[sin]

```
sin ▮.36²
```

■ Using Replay Memory

The last calculation performed is always stored into replay memory. You can recall the contents of the replay memory by pressing ◀ or ▶.

If you press ▶, the calculation appears with the cursor at the beginning. Pressing ◀ causes the calculation to appear with the cursor at the end. You can make changes in the calculation as you wish and then execute it again.

Example 1 **To perform the following two calculations**
4.12 × <u>6.4</u> = 26.368
4.12 × <u>7.1</u> = 29.252

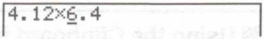
[AC] [4] [•] [1] [2] [×] [6] [•] [4] [EXE]

```
4.12×6.4
                26.368
```

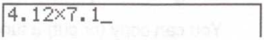
◀ ◀ ◀ ◀

```
4.12×▮.4
```

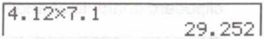
[SHIFT] [DEL](INS)


4.12×6.4

[7] [.] [1]


4.12×7.1_

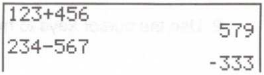
[EXE]


4.12×7.1
29.252

After you press [AC], you can press ▲ or ▼ to recall previous calculations, in sequence from the newest to the oldest (Multi-Replay Function). Once you recall a calculation, you can use ▶ and ◀ to move the cursor around the calculation and make changes in it to create a new calculation.

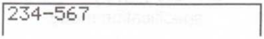
Example 2

[AC] [1] [2] [3] [+] [4] [5] [6] [EXE]
[2] [3] [4] [−] [5] [6] [7] [EXE]

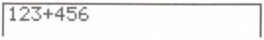

123+456
579
234-567
-333

[AC]

▲ (One calculation back)


234-567

▲ (Two calculations back)

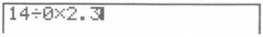

123+456

- A calculation remains stored in replay memory until you perform another calculation.
- The contents of replay memory are not cleared when you press the [AC] key, so you can recall a calculation and execute it even after pressing the [AC] key.

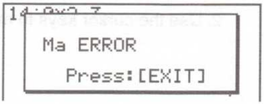
■ Making Corrections in the Original Calculation

Example **14 ÷ 0 × 2.3 entered by mistake for 14 ÷ 10 × 2.3**

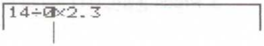
[AC] [1] [4] [÷] [0] [×] [2] [.] [3]


14÷0×2.3

[EXE]

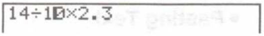

Ma ERROR
Press:[EXIT]

Press [EXIT].


14÷0×2.3

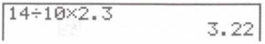
Cursor is positioned automatically at the location of the cause of the error.

Make necessary changes.
◀ [1]


14÷10×2.3

Execute again.

[EXE]

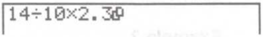

14÷10×2.3
3.22

■ Using the Clipboard for Copy and Paste

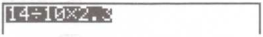
You can copy (or cut) a function, command, or other input to the clipboard, and then paste the clipboard contents at another location.

• To specify the copy range

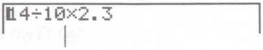
1. Move the cursor (❚) to the beginning or end of the range of text you want to copy and then press SHIFT 8 (CLIP). This changes the cursor to "⧉".


14÷10×2.3⧉

2. Use the cursor keys to move the cursor and highlight the range of text you want to copy.


14÷10×2.3

3. Press F1 (COPY) to copy the highlighted text to the clipboard, and exit the copy range specification mode.

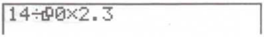

14÷10×2.3

The selected characters are not changed when you copy them.

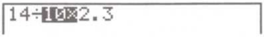
To cancel text highlighting without performing a copy operation, press EXIT.

• To cut the text

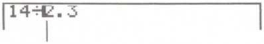
1. Move the cursor (❚) to the beginning or end of the range of text you want to cut and then press SHIFT 8 (CLIP). This changes the cursor to "⧉".


14÷⧉0×2.3

2. Use the cursor keys to move the cursor and highlight the range of text you want to cut.


14÷10×2.3

3. Press F2 (CUT) to cut the highlighted text to the clipboard.

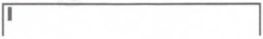

14÷2.3

Cutting causes the original characters to be deleted.

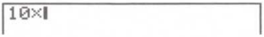
• Pasting Text

Move the cursor to the location where you want to paste the text, and then press SHIFT 9 (PASTE). The contents of the clipboard are pasted at the cursor position.

AC


❚

SHIFT 9 (PASTE)

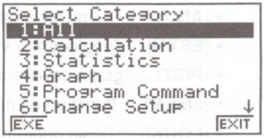

10×❚

■ Catalog Function

The Catalog is an alphabetic list of all the commands available on this calculator. You can input a command by calling up the Catalog and then selecting the command you want.

• To use the Catalog to input a command

1. Press SHIFT 4 (CATALOG) to display an alphabetic Catalog of commands.
   - The screen that appears first is the last one you used for command input.
2. Press F6 (CTGY) to display the category list.
   - You can skip this step and go straight to step 5, if you want.

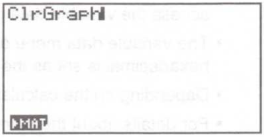


```
Select Category
 1:All
 2:Calculation
 3:Statistics
 4:Graph
 5:Program Command
 6:Change Setup    ↓
EXE            EXIT
```

3. Use the cursor keys (▲, ▼) to highlight the command category you want, and then press F1 (EXE) or EXE.
   - This displays a list of commands in the category you selected.
4. Input the first letter of the command you want to input. This will display the first command that starts with that letter.
5. Use the cursor keys (▲, ▼) to highlight the command you want to input, and then press F1 (INPUT) or EXE.

Example **To use the Catalog to input the ClrGraph command**

AC SHIFT 4 (CATALOG) ln (C) ▼~▼ EXE



```
ClrGraph▌




▸MAT
```

Pressing EXIT or SHIFT EXIT (QUIT) closes the Catalog.

4. Option (OPTN) Menu

The option menu gives you access to scientific functions and features that are not marked on the calculator's keyboard. The contents of the option menu differ according to the mode you are in when you press the OPTN key.

- The option menu does not appear if you press OPTN while binary, octal, decimal, or hexadecimal is set as the default number system.
- For details about the commands included on the option (OPTN) menu, see the "OPTN key" item in the "**PRGM** Mode Command List" (page 8-37).
- The meanings of the option menu items are described in the sections that cover each mode.

The following list shows the option menu that is displayed when the **RUN•MAT** or **PRGM** mode is selected.

- {**LIST**} ... {list function menu}
- {**MAT**} ... {matrix operation menu}

- {**CPLX**} ... {complex number calculation menu}
- {**CALC**} ... {functional analysis menu}
- {**STAT**} ... {menu for paired-variable statistical estimated value, distribution, standard deviation, variance, and test functions}
- {**CONV**} ... {metric conversion menu}
- {**HYP**} ... {hyperbolic calculation menu}
- {**PROB**} ... {probability/distribution calculation menu}
- {**NUM**} ... {numeric calculation menu}
- {**ANGL**} ... {menu for angle/coordinate conversion, sexagesimal input/conversion}
- {**ESYM**} ... {engineering symbol menu}
- {**PICT**} ... {graph save/recall menu}
- {**FMEM**} ... {function memory menu}
- {**LOGIC**} ... {logic operator menu}
- {**CAPT**} ... {screen capture menu}
- {**TVM**} ... {financial calculation menu}

5. Variable Data (VARS) Menu

To recall variable data, press VARS to display the variable data menu.

{**V-WIN**}/{**FACT**}/{**STAT**}/{**GRPH**}/{**DYNA**}/{**TABL**}/{**RECR**}/{**EQUA**}/{**TVM**}/{**Str**}

- Note that the EQUA and TVM items appear for function keys (F3 and F4) only when you access the variable data menu from the **RUN•MAT** or **PRGM** mode.
- The variable data menu does not appear if you press VARS while binary, octal, decimal, or hexadecimal is set as the default number system.
- Depending on the calculator model, some menu items may not be included.
- For details about the commands included on the variable data (VARS) menu, see the "VARS key" item in the "**PRGM** Mode Command List" (page 8-37).

• V-WIN — Recalling V-Window values

- {**X**}/{**Y**}/{**T,θ**} ... {x-axis menu}/{y-axis menu}/{T,θ menu}
- {**R-X**}/{**R-Y**}/{**R-T,θ**} ... {x-axis menu}/{y-axis menu}/{T,θ menu} for right side of Dual Graph
  - {**min**}/{**max**}/{**scal**}/{**dot**}/{**ptch**} ... {minimum value}/{maximum value}/{scale}/{dot value*[1]}/{pitch}

[*1] The dot value indicates the display range (Xmax value – Xmin value) divided by the screen dot pitch (126). The dot value is normally calculated automatically from the minimum and maximum values. Changing the dot value causes the maximum to be calculated automatically.

• FACT — Recalling zoom factors

- {**Xfct**}/{**Yfct**} ... {x-axis factor}/{y-axis factor}

- **STAT — Recalling statistical data**
  - {**X**} ... {single-variable, paired-variable x-data}
    - {n}/{$\bar{x}$}/{Σx}/{Σx^2}/{σ_x}/{s_x}/{**minX**}/{**maxX**} ... {number of data}/{mean}/{sum}/{sum of squares}/{population standard deviation}/{sample standard deviation}/{minimum value}/{maximum value}
  - {**Y**} ... {paired-variable y-data}
    - {$\bar{y}$}/{Σy}/{Σy^2}/{Σxy}/{σ_y}/{s_y}/{**minY**}/{**maxY**} ... {mean}/{sum}/{sum of squares}/{sum of products of x-data and y-data}/{population standard deviation}/{sample standard deviation}/{minimum value}/{maximum value}
  - {**GRPH**} ... {graph data menu}
    - {a}/{b}/{c}/{d}/{e} ... {regression coefficient and polynomial coefficients}
    - {r}/{r^2} ... {correlation coefficient}/{coefficient of determination}
    - {**MSe**} ... {mean square error}
    - {$\mathbf{Q_1}$}/{$\mathbf{Q_3}$} ... {first quartile}/{third quartile}
    - {**Med**}/{**Mod**} ... {median}/{mode} of input data
    - {**Strt**}/{**Pitch**} ... histogram {start division}/{pitch}
  - {**PTS**} ... {summary point data menu}
    - {x_1}/{y_1}/{x_2}/{y_2}/{x_3}/{y_3} ... {coordinates of summary points}
  - {**INPT**} ... {statistical calculation input values}
    - {n}/{$\bar{x}$}/{s_x}/{n_1}/{n_2}/{$\bar{x}_1$}/{$\bar{x}_2$}/{s_{x1}}/{s_{x2}}/{s_p} ... {size of sample}/{mean of sample}/{sample standard deviation}/{size of sample 1}/{size of sample 2}/{mean of sample 1}/{mean of sample 2}/{standard deviation of sample 1}/{standard deviation of sample 2}/{standard deviation of sample p}
  - {**RESLT**} ... {statistical calculation output values}
    - {**TEST**} ... {test calculation results}
      - {p}/{z}/{t}/{**Chi**}/{F}/{$\hat{p}$}/{$\hat{p}_1$}/{$\hat{p}_2$}/{df}/{s_e}/{r}/{r^2}/{**pa**}/{**Fa**}/{**Adf**}/{**SSa**}/{**MSa**}/{**pb**}/{**Fb**}/{**Bdf**}/{**SSb**}/{**MSb**}/{**pab**}/{**Fab**}/{**ABdf**}/{**SSab**}/{**MSab**}/{**Edf**}/{**SSe**}/{**MSe**}

        ... {p-value}/{z score}/{t score}/{χ^2 value}/{F value}/{estimated sample proportion}/{estimated proportion of sample 1}/{estimated proportion of sample 2}/{degrees of freedom}/{standard error}/{correlation coefficient}/{coefficient of determination}/{factor A p-value}/{factor A F value}/{factor A degrees of freedom}/{factor A sum of squares}/{factor A mean squares}/{factor B p-value}/{factor B F value}/{factor B degrees of freedom}/{factor B sum of squares}/ {factor B mean squares}/{factor AB p-value}/{factor AB F value}/{factor AB degrees of freedom}/{factor AB sum of squares}/{factor AB mean squares}/{error degrees of freedom}/{error sum of squares}/{error mean squares}
    - {**INTR**} ... {confidence interval calculation results}
      - {**Left**}/{**Right**}/{$\hat{p}$}/{$\hat{p}_1$}/{$\hat{p}_2$}/{df} ... {confidence interval lower limit (left edge)}/{confidence interval upper limit (right edge)}/{estimated sample proportion}/{estimated proportion of sample 1}/{estimated proportion of sample 2}/{degrees of freedom}
    - {**DIST**} ... {distribution calculation results}
      - {p}/{**xInv**}/{**x1Inv**}/{**x2Inv**}/{**zLow**}/{**zUp**}/{**tLow**}/{**tUp**} ... {probability distribution or cumulative distribution calculation result (p-value)}/{inverse Student-t, χ^2, F, binomial, Poisson, geometric or hypergeometric cumulative distribution calculation result}/{inverse normal cumulative distribution upper limit (right edge) or lower limit (left edge)}/{inverse normal cumulative distribution upper limit (right edge)}/{normal cumulative distribution lower limit (left edge)}/{normal cumulative distribution upper limit (right edge)}/{Student-t cumulative distribution lower limit (left edge)}/{Student-t cumulative distribution upper limit (right edge)}

- **GRPH — Recalling graph functions**
  - {**Y**}/{**r**} ... {rectangular coordinate or inequality function}/{polar coordinate function}
  - {**Xt**}/{**Yt**} ... parametric graph function {Xt}/{Yt}
  - {**X**} ... {X=constant graph function}
  - Press these keys before inputting a value to specify a memory area.

- **DYNA — Recalling dynamic graph setup data**
  - {**Strt**}/{**End**}/{**Pitch**} ... {coefficient range start value}/{coefficient range end value}/{coefficient value increment}

- **TABL — Recalling table setup and content data**
  - {**Strt**}/{**End**}/{**Pitch**} ... {table range start value}/{table range end value}/{table value increment}
  - {**Reslt**[*1]} ... {matrix of table contents}

[*1] The Reslt item appears only when the TABL menu is displayed in the **RUN•MAT** and **PRGM** modes.

- **RECR — Recalling recursion formula[*1], table range, and table content data**
  - {**FORM**} ... {recursion formula data menu}
    - {a_n}/{a_{n+1}}/{a_{n+2}}/{b_n}/{b_{n+1}}/{b_{n+2}}/{c_n}/{c_{n+1}}/{c_{n+2}} ... {a_n}/{a_{n+1}}/{a_{n+2}}/{b_n}/{b_{n+1}}/{b_{n+2}}/{c_n}/{c_{n+1}}/{c_{n+2}} expressions
  - {**RANG**} ... {table range data menu}
    - {**Strt**}/{**End**} ... table range {start value}/{end value}
    - {a_0}/{a_1}/{a_2}/{b_0}/{b_1}/{b_2}/{c_0}/{c_1}/{c_2} ... {a_0}/{a_1}/{a_2}/{b_0}/{b_1}/{b_2}/{c_0}/{c_1}/{c_2} value
    - {**a_nSt**}/{**b_nSt**}/{**c_nSt**} ... origin of {a_n}/{b_n}/{c_n} recursion formula convergence/divergence graph (WEB graph)
  - {**Reslt**[*2]} ... {matrix of table contents[*3]}

[*1] An error occurs when there is no function or recursion formula numeric table in memory.

[*2] "Reslt" is available only in the **RUN•MAT** and **PRGM** modes.

[*3] Table contents are stored automatically in Matrix Answer Memory (MatAns).

- **EQUA — Recalling equation coefficients and solutions[*1] [*2]**
  - {**S-Rlt**}/{**S-Cof**} ... matrix of {solutions}/{coefficients} for linear equations with two through six unknowns[*3]
  - {**P-Rlt**}/{**P-Cof**} ... matrix of {solution}/{coefficients} for a quadratic or cubic equation

[*1] Coefficients and solutions are stored automatically in Matrix Answer Memory (MatAns).

[*2] The following conditions cause an error.

- When there are no coefficients input for the equation
- When there are no solutions obtained for the equation

[*3] Coefficient and solution memory data for a linear equation cannot be recalled at the same time.

- **TVM — Recalling financial calculation data**
  - {*n*}/{*I%*}/{*PV*}/{*PMT*}/{*FV*} ... {payment periods (installments)}/{annual interest rate}/{present value}/{payment}/{future value}
  - {*P/Y*}/{*C/Y*} ... {installment periods per year}/{compounding periods per year}

- **Str — Str command**
  - {**Str**} ... {string memory}

6. Program (PRGM) Menu

To display the program (PRGM) menu, first enter the **RUN•MAT** or **PRGM** mode from the Main Menu and then press SHIFT VARS (PRGM). The following are the selections available in the program (PRGM) menu.

- {**COM**} ...... {program command menu}
- {**CTL**} .... {program control command menu}
- {**JUMP**} ..... {jump command menu}
- {**?**} .... {input command}
- {**◢**} .... {output command}
- {**CLR**} .... {clear command menu}
- {**DISP**} ...... {display command menu}
- {**REL**} .... {conditional jump relational operator menu}
- {**I/O**} .... {I/O control/transfer command menu}
- {**:**} .... {multi-statement command}
- {**STR**} .... {string command}

The following function key menu appears if you press SHIFT VARS (PRGM) in the **RUN•MAT** mode or the **PRGM** mode while binary, octal, decimal, or hexadecimal is set as the default number system.

- {**Prog**}....... {program recall}
- {**JUMP**}/{**?**}/{**◢**}/{**REL**}/{**:**}

The functions assigned to the function keys are the same as those in the Comp mode.

For details on the commands that are available in the various menus you can access from the program menu, see "Chapter 8 Programming".

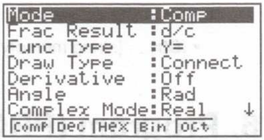
7. Using the Setup Screen

The mode's Setup screen shows the current status of mode settings and lets you make any changes you want. The following procedure shows how to change a setup.

• To change a mode setup

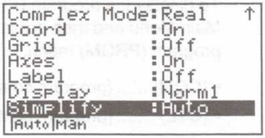
1. Select the icon you want and press EXE to enter a mode and display its initial screen. Here we will enter the **RUN•MAT** mode.

2. Press SHIFT MENU (SET UP) to display the mode's Setup screen.
   - This Setup screen is just one possible example. Actual Setup screen contents will differ according to the mode you are in and that mode's current settings.



```
Mode          :Comp
Frac Result   :d/c
Func Type     :Y=
Draw Type     :Connect
Derivative    :Off
Angle         :Rad
Complex Mode:Real   ↓
Comp|Dec|Hex|Bin|Oct
```

⋮



```
Complex Mode:Real   ↑
Coord         :On
Grid          :Off
Axes          :On
Label         :Off
Display       :Norm1
Simplify      :Auto
Auto|Man
```

3. Use the ▲ and ▼ cursor keys to move the highlighting to the item whose setting you want to change.

4. Press the function key (F1 to F6) that is marked with the setting you want to make.

5. After you are finished making any changes you want, press EXIT to exit the Setup screen.

■ Setup Screen Function Key Menus

This section details the settings you can make using the function keys in the Setup screen.
〰 indicates default setting.

• Mode (calculation/binary, octal, decimal, hexadecimal mode)

- {**Comp**} ... {arithmetic calculation mode}
- {**Dec**}/{**Hex**}/{**Bin**}/{**Oct**} ... {decimal}/{hexadecimal}/{binary}/{octal}

• Frac Result (fraction result display format)

- {**d/c**}/{**ab/c**} ... {improper}/{mixed} fraction

• Func Type (graph function type)

Pressing one of the following function keys also switches the function of the X,θ,T key.

- {**Y=**}/{**r=**}/{**Parm**}/{**X=**} ... {rectangular coordinate (Y=$f(x)$ type)}/{polar coordinate}/{parametric}/{rectangular coordinate (X=$f(y)$ type)} graph
- {**Y>**}/{**Y<**}/{**Y≥**}/{**Y≤**} ... {$y>f(x)$}/{$y<f(x)$}/{$y\geq f(x)$}/{$y\leq f(x)$} inequality graph
- {**X>**}/{**X<**}/{**X≥**}/{**X≤**} ... {$x>f(y)$}/{$x<f(y)$}/{$x\geq f(y)$}/{$x\leq f(y)$} inequality graph

• Draw Type (graph drawing method)

- {**Con**}/{**Plot**} ... {connected points}/{unconnected points}

• Derivative (derivative value display)

- {**On**}/{**Off**} ... {display on}/{display off} while Graph-to-Table, Table & Graph, and Trace are being used

• Angle (default angle unit)

- {**Deg**}/{**Rad**}/{**Gra**} ... {degrees}/{radians}/{grads}

- **Complex Mode**
  - {**Real**} ... {calculation in real number range only}
  - {$a+bi$}/{$r\angle\theta$} ... {rectangular format}/{polar format} display of a complex calculation
- **Coord (graph pointer coordinate display)**
  - {**On**}/{**Off**} ... {display on}/{display off}
- **Grid (graph gridline display)**
  - {**On**}/{**Off**} ... {display on}/{display off}
- **Axes (graph axis display)**
  - {**On**}/{**Off**} ... {display on}/{display off}
- **Label (graph axis label display)**
  - {**On**}/{**Off**} ... {display on}/{display off}
- **Display (display format)**
  - {**Fix**}/{**Sci**}/{**Norm**}/{**Eng**} ... {fixed number of decimal places specification}/{number of significant digits specification}/{normal display setting}/{engineering mode}
- **Stat Wind (statistical graph V-Window setting method)**
  - {**Auto**}/{**Man**} ... {automatic}/{manual}
- **Resid List (residual calculation)**
  - {**None**}/{**LIST**} ... {no calculation}/{list specification for the calculated residual data}
- **List File (list file display settings)**
  - {**FILE**} ... {settings of list file on the display}
- **Sub Name (list naming)**
  - {**On**}/{**Off**} ... {display on}/{display off}
- **Graph Func (function display during graph drawing and trace)**
  - {**On**}/{**Off**} ... {display on}/{display off}
- **Dual Screen (dual screen mode status)**
  - {**G+G**}/{**GtoT**}/{**Off**} ... {graphing on both sides of dual screen}/{graph on one side and numeric table on the other side of dual screen}/{dual screen off}
- **Simul Graph (simultaneous graphing mode)**
  - {**On**}/{**Off**} ... {simultaneous graphing on (all graphs drawn simultaneously)}/{simultaneous graphing off (graphs drawn in area numeric sequence)}
- **Background (graph display background)**
  - {**None**}/{**PICT**} ... {no background}/{graph background picture specification}
- **Sketch Line (overlaid line type)**
  - {—}/{━}/{·····}/{·······} ... {normal}/{thick}/{broken}/{dotted}
- **Dynamic Type (dynamic graph type)**
  - {**Cnt**}/{**Stop**} ... {non-stop (continuous)}/{automatic stop after 10 draws}

- **Locus (dynamic graph locus mode)**
  - {On}/{Off} ... {locus drawn}/{locus not drawn}
- **Y=Draw Speed (dynamic graph draw speed)**
  - {Norm}/{High} ... {normal}/{high-speed}
- **Variable (table generation and graph draw settings)**
  - {RANG}/{LIST} ... {use table range}/{use list data}
- **Σ Display (Σ value display in recursion table)**
  - {On}/{Off} ... {display on}/{display off}
- **Slope (display of derivative at current pointer location in conic section graph)**
  - {On}/{Off} ... {display on}/{display off}
- **Payment (payment period setting)**
  - {BGN}/{END} ... {beginning}/{end} setting of payment period
- **Date Mode (number of days per year setting)**
  - {365}/{360} ... interest calculations using {365}[*1]/{360} days per year

[*1] The 365-day year must be used for date calculations in the **TVM** mode. Otherwise, an error occurs.

- **Periods/YR. (payment interval specification)**
  - {Annu}/{Semi} ... {annual}/{semiannual}
- **Ineq Type (inequality fill specification)**
  - {AND}/{OR} ... When graphing multiple inequalities, {fill areas where all inequality conditions are satisfied}/{fill areas where each inequality condition is satisfied}
- **Simplify (calculation result auto/manual reduction specification)**
  - {Auto}/{Man} ... {auto reduce and display}/{display without reduction}
- **Q1Q3 Type (Q_1/Q_3 calculation formulas)**
  - {Std}/{OnData} ... {Divide total population on its center point between upper and lower groups, with the median of the lower group Q1 and the median of the upper group Q3}/{Make the value of element whose cumulative frequency ratio is greater than 1/4 and nearest to 1/4 Q1 and the value of element whose cumulative frequency ratio is greater than 3/4 and nearest to 3/4 Q3}

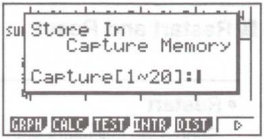
8. Using Screen Capture

Any time while operating the calculator, you can capture an image of the current screen and save it in capture memory.

• To capture a screen image

1. Operate the calculator and display the screen you want to capture.

2. Press SHIFT 7(CAPTURE).
   - This displays a memory area selection dialog box.


Store In
Capture Memory

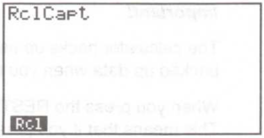
Capture[1~20]:▮

3. Input a value from 1 to 20 and then press EXE.
   - This will capture the screen image and save it in capture memory area named "Capt *n*" (*n* = the value you input).

- You cannot capture the screen image of a message indicating that an operation or data communication is in progress.
- A memory error will occur if there is not enough room in main memory to store the screen capture.

• To recall a screen image from capture memory

1. In the **RUN•MAT** mode, press OPTN F6(▷) F6(▷) F5(CAPT) F1(RCL).


RclCapt

2. Enter a capture memory number in the range of 1 to 20, and then press EXE.
   - This displays the image stored in the capture memory you specified.
3. To exit the image display and return to the screen you started from in step 1, press EXIT.

- You can also use the RclCapt command in a program to recall a screen image from capture memory.

9. When you keep having problems...

If you keep having problems when you are trying to perform operations, try the following before assuming that there is something wrong with the calculator.

■ Getting the Calculator Back to its Original Mode Settings

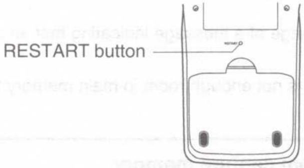
1. From the Main Menu, enter the **SYSTEM** mode.
2. Press F5(RSET).
3. Press F1(STUP), and then press F1(Yes).
4. Press EXIT MENU to return to the Main Menu.

Now enter the correct mode and perform your calculation again, monitoring the results on the display.

Restart and Reset

• Restart

Should the calculator start to act abnormally, you can restart it by pressing the RESTART button. Note, however, that you should only use the RESTART button only as a last resort. Normally, pressing the RESTART button reboots the calculator's operating system, so programs, graph functions and other data in calculator memory is retained.



Important!

The calculator backs up user data (main memory) when you turn power off and loads the backed up data when you turn power back on.

When you press the RESTART button, the calculator restarts and loads backed up data. This means that if you press the RESTART button after you edit a program, graph function, or other data, any data that has not been backed up will be lost.

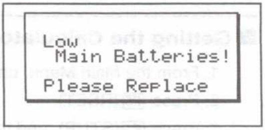
• Reset

Use reset when you want to delete all data currently in calculator memory and return all mode settings to their initial defaults.

Before performing the reset operation, first make a written copy of all important data. For details, see "Reset" (page 10-3).

Low Battery Message

If the following message appears on the display, immediately turn off the calculator and replace batteries as instructed.



```
Low
 Main Batteries!
Please Replace
```

If you continue using the calculator without replacing batteries, power will automatically turn off to protect memory contents. Once this happens, you will not be able to turn power back on, and there is the danger that memory contents will be corrupted or lost entirely.

- You will not be able to perform data communications operations after the low battery message appears.

Chapter 2 Manual Calculations

1. Basic Calculations

■ Arithmetic Calculations

- Enter arithmetic calculations as they are written, from left to right.
- Use the (−) key to input the minus sign before a negative value.
- Calculations are performed internally with a 15-digit mantissa. The result is rounded to a 10-digit mantissa before it is displayed.
- For mixed arithmetic calculations, multiplication and division are given priority over addition and subtraction.

Example	Operation
56 × (−12) ÷ (−2.5) = 268.8	56 × (−) 12 ÷ (−) 2.5 EXE
(2 + 3) × 10² = 500	(2 + 3) × 1 EXP 2 EXE
2 + 3 × (4 + 5) = 29	2 + 3 × (4 + 5 EXE [1]
$\frac{6}{4\times5} = 0.3$	6 ÷ (4 × 5) EXE

[1] Final closed parentheses (immediately before operation of the EXE key) may be omitted, no matter how many are required.

■ Number of Decimal Places, Number of Significant Digits, Normal Display Range

[SET UP]- Display -[Fix]/[Sci]/[Norm]

- Even after you specify the number of decimal places or the number of significant digits, internal calculations are still performed using a 15-digit mantissa, and displayed values are stored with a 10-digit mantissa. Use Rnd of the Numeric Calculation Menu (NUM) (page 2-9) to round the displayed value off to the number of decimal place and significant digit settings.
- Number of decimal place (Fix) and significant digit (Sci) settings normally remain in effect until you change them or until you change the normal display range (Norm) setting.

Example 1 **100 ÷ 6 = 16.66666666...**

Condition	Operation	Display
	100 ÷ 6 EXE	16.66666667
4 decimal places	SHIFT MENU (SET UP) ▲ ▲ F1 (Fix) 4 EXE EXIT EXE	16.6667 [1]
5 significant digits	SHIFT MENU (SET UP) ▲ ▲ F2 (Sci) 5 EXE EXIT EXE	1.6667E+01 [1]
Cancels specification	SHIFT MENU (SET UP) ▲ ▲ F3 (Norm) EXIT EXE	16.66666667

[1] Displayed values are rounded off to the place you specify.

Example 2 200 ÷ 7 × 14 = 400

Condition	Operation	Display
	200 ÷ 7 × 14 EXE	400
3 decimal places	SHIFT MENU (SET UP) ▲ ▲ F1 (Fix) 3 EXE EXIT EXE	 400.000
Calculation continues using display capacity of 10 digits	200 ÷ 7 EXE × 14 EXE	28.571 Ans × ▮ 400.000

- If the same calculation is performed using the specified number of digits:

	200 ÷ 7 EXE	28.571
The value stored internally is rounded off to the number of decimal places specified on the Setup screen.	OPTN F6 (▷) F4 (NUM) F4 (Rnd) EXE	28.571
	×	Ans × ▮
	14 EXE	399.994
	200 ÷ 7 EXE	28.571
You can also specify the number of decimal places for rounding of internal values for a specific calculation. (Example: To specify rounding to two decimal places)	F6 (▷) F1 (RndFi) SHIFT (−) (Ans) , 2)	RndFix(Ans,2)
	EXE	28.570
	×	Ans × ▮
	14 EXE	399.980

■ Calculation Priority Sequence

This calculator employs true algebraic logic to calculate the parts of a formula in the following order:

① Type A functions
  - Coordinate transformation Pol (x, y), Rec (r, θ)
  - Functions that include parentheses (such as derivatives, integrations, Σ, etc.)
    d/dx, d^2/dx^2, $\int dx$, Σ, Solve, FMin, FMax, List→Mat, Fill, Seq, SortA, SortD, Min, Max, Median, Mean, Augment, Mat→List, P(, Q(, R(, t(, RndFix, $\log_a b$
  - Composite functions*1, List, Mat, fn, **Y**n, **r**n, **X**tn, **Y**tn, **X**n

② Type B functions
With these functions, the value is entered and then the function key is pressed.
x^2, x^{-1}, $x!$, ° ' ", ENG symbols, angle unit °, r, g

③ Power/root ^(x^y), $\sqrt[x]{\ }$

④ Fractions $a\,^b/_c$

⑤ Abbreviated multiplication format in front of π, memory name, or variable name.
2π, 5A, Xmin, F Start, etc.

⑥ Type C functions
With these functions, the function key is pressed and then the value is entered.
$\sqrt{\ }$, $\sqrt[3]{\ }$, log, ln, e^x, 10^x, sin, cos, tan, $\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$, sinh, cosh, tanh, $\sinh^{-1}$, $\cosh^{-1}$,

$\tanh^{-1}$, (–), d, h, b, o, Neg, Not, Det, Trn, Dim, Identity, Ref, Rref, Sum, Prod, Cuml, Percent, ⊿List, Abs, Int, Frac, Intg, Arg, Conjg, ReP, ImP

⑦ Abbreviated multiplication format in front of Type A functions, Type C functions, and parenthesis.
$2\sqrt{3}$, A log2, etc.

⑧ Permutation, combination nPr, nCr

⑨ Metric conversion commands

⑩ ×, ÷, Int÷, Rnd

⑪ +, –

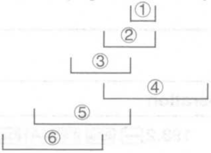
⑫ Relational operators =, ≠, >, <, ≥, ≤

⑬ And (logical operator), and (bitwise operator)

⑭ Or, Xor (logical operator), or, xor, xnor (bitwise operator)

*1 You can combine the contents of multiple function memory (fn) locations or graph memory (**Y**n, **r**n, **X**tn, **Y**tn, **X**n) locations into composite functions. Specifying fn1(fn2), for example, results in the composite function fn1∘fn2 (see page 5-7). A composite function can consist of up to five functions.

Example **2 + 3 × (log sin$2\pi^2$ + 6.8) = 22.07101691 (angle unit = Rad)**



- You cannot use a differential, quadratic differential, integration, Σ, maximum/minimum value, Solve, RndFix or log$_a$b calculation expression inside of a RndFix calculation term.
- When functions with the same priority are used in series, execution is performed from right to left.

  $e^x\ln\sqrt{120} \rightarrow e^x\{\ln(\sqrt{120})\}$

  Otherwise, execution is from left to right.
- Compound functions are executed from right to left.
- Anything contained within parentheses receives highest priority.

■ Multiplication Operations without a Multiplication Sign

You can omit the multiplication sign (×) in any of the following operations.

- Before Type A functions (① on page 2-2) and Type C functions (⑥ on page 2-2), except for negative signs

Example 1 **2sin30, 10log1.2, $2\sqrt{3}$, 2Pol(5, 12), etc.**

- Before constants, variable names, memory names

Example 2 **2π, 2AB, 3Ans, $3Y_1$, etc.**

- Before an open parenthesis

Example 3 **3(5 + 6), (A + 1)(B – 1), etc.**

■ Overflow and Errors

Exceeding a specified input or calculation range, or attempting an illegal input causes an error message to appear on the display. Further operation of the calculator is impossible while an error message is displayed. For details, see the "Error Message Table" on page α-1.

- Most of the calculator's keys are inoperative while an error message is displayed. Press EXIT to clear the error and return to normal operation.

■ Memory Capacity

Each time you press a key, either one byte or two bytes is used. Some of the functions that require one byte are: 1, 2, 3, sin, cos, tan, log, ln, √, and π.
Some of the functions that take up two bytes are d/dx(, Mat, Xmin, If, For, Return, DrawGraph, SortA(, PxlOn, Sum, and a_{n+1}.

2. Special Functions

■ Calculations Using Variables

Example	Operation	Display
	193.2 → ALPHA X,θ,T (A) EXE	**193.2**
193.2 ÷ 23 = 8.4	**ALPHA X,θ,T (A) ÷ 23 EXE**	**8.4**
193.2 ÷ 28 = 6.9	**ALPHA X,θ,T (A) ÷ 28 EXE**	**6.9**

■ Memory

• Variables (Alpha Memory)

This calculator comes with 28 variables as standard. You can use variables to store values you want to use inside of calculations. Variables are identified by single-letter names, which are made up of the 26 letters of the alphabet, plus r and θ. The maximum size of values that you can assign to variables is 15 digits for the mantissa and 2 digits for the exponent.

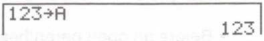
- Variable contents are retained even when you turn power off.

• To assign a value to a variable

[value] → [variable name] EXE

Example 1 **To assign 123 to variable A**

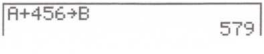
AC 1 2 3 → ALPHA X,θ,T (A) EXE



```
123→A
                 123
```

Example 2 **To add 456 to variable A and store the result in variable B**

AC ALPHA X,θ,T (A) + 4 5 6 →
ALPHA log (B) EXE



```
A+456→B
                 579
```

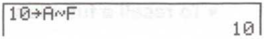
• To assign the same value to more than one variable

[value] → [first variable name] ALPHA F3 (~) [last variable name] EXE

- You cannot use "r" or "θ" as a variable name.

Example **To assign a value of 10 to variables A through F**

AC 1 0 → ALPHA X,θ,T (A)
ALPHA F3 (~) ALPHA tan (F) EXE



```
10→A~F
                10
```

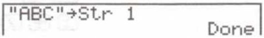
• String Memory

You can store up to 20 strings (named Str 1 to Str 20) in string memory. Stored strings can be output to the display or used inside functions and commands that support the use of strings as arguments.

For details about string operations, see "Strings" (page 8-18).

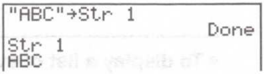
Example **To assign string "ABC" to Str 1 and then output Str 1 to the display**

AC SHIFT ALPHA (A-LOCK) EXP (") X,θ,T (A)
log (B) ln (C) EXP (") ALPHA (Releases Alpha Lock.)
→ VARS F6 (▷) F5 (Str) 1 EXE



```
"ABC"→Str 1
              Done
```

F5 (Str) 1 EXE



```
"ABC"→Str 1
              Done
Str 1
ABC
```

String is displayed justified left.

• Function Memory [OPTN]-[FMEM]

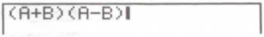
Function memory is convenient for temporary storage of often-used expressions. For longer term storage, we recommend that you use the **GRAPH** mode for expressions and the **PRGM** mode for programs.

- {**STO**}/{**RCL**}/{**fn**}/{**SEE**} ... {function store}/{function recall}/{function area specification as a variable name inside an expression}/{function list}

• To store a function

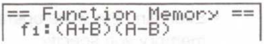
Example **To store the function (A+B) (A–B) as function memory number 1**

(ALPHA X,θ,T (A) + ALPHA log (B))
(ALPHA X,θ,T (A) − ALPHA log (B))



```
(A+B)(A-B)▌
```

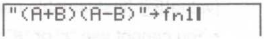
OPTN F6 (▷) F6 (▷) F3 (FMEM)
F1 (STO) 1 EXE



```
== Function Memory ==
 f1:(A+B)(A-B)
```

EXIT EXIT EXIT

- If the function memory number to which you store a function already contains a function, the previous function is replaced with the new one.
- You can also use → to store a function in function memory in a program. In this case, you must enclose the function inside of double quotation marks.

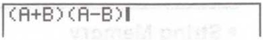


```
"(A+B)(A-B)"→fn1▌
```

• To recall a function

Example **To recall the contents of function memory number 1**

AC OPTN F6(▷) F6(▷) F3(FMEM)
F2(RCL) 1 EXE

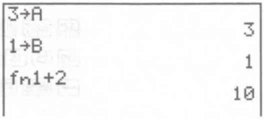


```
(A+B)(A-B)▌
```

- The recalled function appears at the current location of the cursor on the display.

• To recall a function as a variable

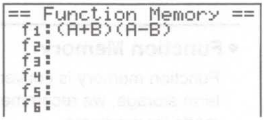
AC 3 → ALPHA X,θ,T(A) EXE
1 → ALPHA log(B) EXE
OPTN F6(▷) F6(▷) F3(FMEM) F3(fn)
1 + 2 EXE



```
3→A
                   3
1→B
                   1
fn1+2
                  10
```

• To display a list of available functions

OPTN F6(▷) F6(▷) F3(FMEM)
F4(SEE)



```
== Function Memory ==
 f1:(A+B)(A-B)
 f2:
 f3:
 f4:
 f5:
 f6:
```

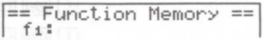
• To delete a function

Example **To delete the contents of function memory number 1**

AC

```
▌
```

OPTN F6(▷) F6(▷) F3(FMEM)
F1(STO) 1 EXE



```
== Function Memory ==
 f1:
```

- Executing the store operation while the display is blank deletes the function in the function memory you specify.

■ Answer Function

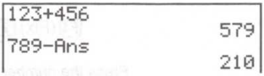
The Answer Function automatically stores the last result you calculated by pressing EXE (unless the EXE key operation results in an error). The result is stored in the answer memory.

- The largest value that the answer memory can hold is 15 digits for the mantissa and 2 digits for the exponent.
- Answer memory contents are not cleared when you press the AC key or when you switch power off.

• To use the contents of the answer memory in a calculation

Example 123 + 456 = 579
789 − 579 = 210

AC 1 2 3 + 4 5 6 EXE
7 8 9 − SHIFT (−)(Ans) EXE



```
123+456
                 579
789-Ans
                 210
```

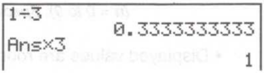
- The answer memory contents are not changed by an operation that assigns values to Alpha memory (such as: 5 → ALPHA log (B) EXE).

■ Performing Continuous Calculations

Answer memory also lets you use the result of one calculation as one of the arguments in the next calculation.

Example 1 ÷ 3 =
1 ÷ 3 × 3 =

AC 1 ÷ 3 EXE
(Continuing) × 3 EXE



```
1÷3
        0.3333333333
Ans×3
                   1
```

Continuous calculations can also be used with Type B functions (x^2, x^{-1}, $x!$, on page 2-2), +, −, ^(x^y), $\sqrt[x]{\ }$, ° ' ", etc.

3. Specifying the Angle Unit and Display Format

Before performing a calculation for the first time, you should use the Setup screen to specify the angle unit and display format.

■ Setting the Angle Unit

[SET UP]- [Angle]

1. On the Setup screen, highlight "Angle".
2. Press the function key for the angle unit you want to specify, then press EXIT.
   - {**Deg**}/{**Rad**}/{**Gra**} ... {degrees}/{radians}/{grads}

- The relationship between degrees, grads, and radians is shown below.

$360° = 2\pi$ radians = 400 grads

$90° = \pi/2$ radians = 100 grads

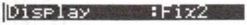
Setting the Display Format [SET UP]- [Display]

1. On the Setup screen, highlight "Display".
2. Press the function key for the item you want to set, then press EXIT.
   - {**Fix**}/{**Sci**}/{**Norm**}/{**Eng**} ... {fixed number of decimal places specification}/{number of significant digits specification}/{normal display}/{Engineering mode}

• To specify the number of decimal places (Fix)

Example **To specify two decimal places**

F1(Fix) 2 EXE


Display :Fix2

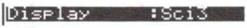
Press the number key that corresponds to the number of decimal places you want to specify (n = 0 to 9).

- Displayed values are rounded off to the number of decimal places you specify.

• To specify the number of significant digits (Sci)

Example **To specify three significant digits**

F2(Sci) 3 EXE


Display :Sci3

Press the number key that corresponds to the number of significant digits you want to specify (n = 0 to 9). Specifying 0 makes the number of significant digits 10.

- Displayed values are rounded off to the number of significant digits you specify.

• To specify the normal display (Norm 1/Norm 2)

Press F3(Norm) to switch between Norm 1 and Norm 2.

Norm 1: 10^{-2} (0.01) $> |x|, |x| \geq 10^{10}$

Norm 2: 10^{-9} (0.000000001) $> |x|, |x| \geq 10^{10}$

• To specify the engineering notation display (Eng mode)

Press F4(Eng) to switch between engineering notation and standard notation. The indicator "/E" is on the display while engineering notation is in effect.

You can use the following symbols to convert values to engineering notation, such as 2,000 (= 2×10^3) → 2k.

E (Exa)	$\times 10^{18}$	m (milli)	$\times 10^{-3}$
P (Peta)	$\times 10^{15}$	μ (micro)	$\times 10^{-6}$
T (Tera)	$\times 10^{12}$	n (nano)	$\times 10^{-9}$
G (Giga)	$\times 10^{9}$	p (pico)	$\times 10^{-12}$
M (Mega)	$\times 10^{6}$	f (femto)	$\times 10^{-15}$
k (kilo)	$\times 10^{3}$		

- The engineering symbol that makes the mantissa a value from 1 to 1000 is automatically selected by the calculator when engineering notation is in effect.

4. Function Calculations

■ Function Menus

This calculator includes five function menus that give you access to scientific functions not printed on the key panel.

- The contents of the function menu differ according to the mode you entered from the Main Menu before you pressed the OPTN key. The following examples show function menus that appear in the **RUN • MAT** or **PRGM** mode.

• Hyperbolic Calculations (HYP) **[OPTN]-[HYP]**

- {**sinh**}/{**cosh**}/{**tanh**} ... hyperbolic {sine}/{cosine}/{tangent}
- {**sinh^{-1}**}/{**cosh^{-1}**}/{**tanh^{-1}**} ... inverse hyperbolic {sine}/{cosine}/{tangent}

• Probability/Distribution Calculations (PROB) **[OPTN]-[PROB]**

- {***x*!**} ... {press after inputting a value to obtain the factorial of the value}
- {***n*Pr**}/{***n*Cr**} ... {permutation}/{combination}
- {**RAND**} ... {random number generation}
  - {**Ran#**}/{**Int**}/{**Norm**}/{**Bin**}/{**List**} ... {random number generation (0 to 1)}/{random integer generation}/{random number generation in accordance with normal distribution based on mean μ and standard deviation σ}/{random number generation in accordance with binomial distribution based on number of trials n and probability p}/{random number generation (0 to 1) and storage of result in ListAns}
- {**P(**}/{**Q(**}/{**R(**} ... normal probability {P(t)}/{Q(t)}/{R(t)}
- {***t*(**} ... {value of normalized variate $t(x)$}

• Numeric Calculations (NUM) **[OPTN]-[NUM]**

- {**Abs**} ... {select this item and input a value to obtain the absolute value of the value}
- {**Int**}/{**Frac**} ... select the item and input a value to extract the {integer}/{fraction} part.
- {**Rnd**} ... {rounds off the value used for internal calculations to 10 significant digits (to match the value in the answer memory), or to the number of decimal places (Fix) and number of significant digits (Sci) specified by you}

- {**Intg**} ... {select this item and input a value to obtain the largest integer that is not greater than the value}
- {**RndFi**} ... {rounds off the value used for internal calculations to specified digits (0 to 9) (see page 2-2).}
- {**GCD**} ... {greatest common divisor for two values}
- {**LCM**} ... {least common multiple for two values}
- {**MOD**} ... {remainder of division (remainder output when n is divided by m)}
- {**MOD・E**} ... {remainder when division is performed on a power value (remainder output when n is raised to p power and then divided by m)}

• Angle Units, Coordinate Conversion, Sexagesimal Operations (ANGL)

[OPTN]-[ANGL]

- {°}/{**r**}/{**g**} ... {degrees}/{radians}/{grads} for a specific input value
- {° ’ ”} ... {specifies degrees (hours), minutes, seconds when inputting a degrees/minutes/seconds value}
- {$\overleftarrow{^\circ\,'\,''}$} ... {converts decimal value to degrees/minutes/seconds value}
  - The {$\overleftarrow{^\circ\,'\,''}$} menu operation is available only when there is a calculation result on the display.
- {**Pol(**}/{**Rec(**} ... {rectangular-to-polar}/{polar-to-rectangular} coordinate conversion
- {**▶DMS**} ... {converts decimal value to sexagesimal value}

• Engineering Symbol (ESYM)

[OPTN]-[ESYM]

- {**m**}/{**μ**}/{**n**}/{**p**}/{**f**} ... {milli (10^{-3})}/{micro (10^{-6})}/{nano (10^{-9})}/{pico (10^{-12})}/{femto (10^{-15})}
- {**k**}/{**M**}/{**G**}/{**T**}/{**P**}/{**E**} ... {kilo (10^{3})}/{mega (10^{6})}/{giga (10^{9})}/{tera (10^{12})}/{peta (10^{15})}/{exa (10^{18})}
- {**ENG**}/{**$\overleftarrow{\text{ENG}}$**} ... shifts the decimal place of the displayed value three digits to the {left}/{right} and {decreases}/{increases} the exponent by three.

  When you are using engineering notation, the engineering symbol is also changed accordingly.
  - The {ENG} and {$\overleftarrow{\text{ENG}}$} menu operations are available only when there is a calculation result on the display.

■ Angle Units

- Be sure to specify Comp for Mode in the Setup screen.

Example	Operation
To convert 4.25 rad to degrees: 243.5070629	SHIFT MENU (SET UP) ▼ ▼ ▼ ▼ ▼ F1 (Deg) EXIT **4.25** OPTN F6 (▷) F5 (ANGL) F2 (r) EXE
47.3° + 82.5rad = 4774.20181°	**47.3** + **82.5** OPTN F6 (▷) F5 (ANGL) F2 (r) EXE
2°20´30˝ + 39´30˝ = 3°00´00˝	**2** OPTN F6 (▷) F5 (ANGL) F4 (° ’ ”) **20** F4 (° ’ ”) **30** F4 (° ’ ”) + **0** F4 (° ’ ”) **39** F4 (° ’ ”) **30** F4 (° ’ ”) EXE F5 ($\overleftarrow{^\circ\,'\,''}$)
2.255° = 2°15´18˝	**2.255** OPTN F6 (▷) F5 (ANGL) F6 (▷) F3 (▶DMS) EXE

Trigonometric and Inverse Trigonometric Functions

- Be sure to set the angle unit before performing trigonometric function and inverse trigonometric function calculations.

$$(90° = \frac{\pi}{2} \text{ radians} = 100 \text{ grads})$$

- Be sure to specify Comp for Mode in the Setup screen.

Example	Operation
$\cos(\frac{\pi}{3}\text{ rad}) = 0.5$	SHIFT MENU (SET UP) ▼ ▼ ▼ ▼ ▼ F2 (Rad) EXIT cos (SHIFT EXP (π) ÷ **3**) EXE
$2 \cdot \sin 45° \times \cos 65° = 0.5976724775$	SHIFT MENU (SET UP) ▼ ▼ ▼ ▼ ▼ F1 (Deg) EXIT **2** × sin **45** × cos **65** EXE *1
$\sin^{-1}0.5 = 30°$ (x when $\sin x = 0.5$)	SHIFT sin ($\sin^{-1}$) **0.5***2 EXE

*1 × can be omitted.

*2 Input of leading zero is not necessary.

Logarithmic and Exponential Functions

- Be sure to specify Comp for Mode in the Setup screen.

Example	Operation
$\log 1.23\ (\log_{10}1.23) = 0.08990511144$	log **1.23** EXE
$\log_2 8 = 3$	OPTN F4 (CALC) F6 (▷) F4 ($\log_a b$) **2** , **8**) EXE
$(-3)^4 = (-3) \times (-3) \times (-3) \times (-3) = 81$	((–) **3**) ∧ **4** EXE
$\sqrt[7]{123}\ (= 123^{\frac{1}{7}}) = 1.988647795$	**7** SHIFT ∧ ($\sqrt[x]{\ }$) **123** EXE

Hyperbolic and Inverse Hyperbolic Functions

- Be sure to specify Comp for Mode in the Setup screen.

Example	Operation
$\sinh 3.6 = 18.28545536$	OPTN F6 (▷) F2 (HYP) F1 (sinh) **3.6** EXE
$\cosh^{-1}\left(\frac{20}{15}\right) = 0.7953654612$	OPTN F6 (▷) F2 (HYP) F5 ($\cosh^{-1}$) (**20** ÷ **15**) EXE

Other Functions

- Be sure to specify Comp for Mode in the Setup screen.

Example	Operation
$\sqrt{2}+\sqrt{5}=3.65028154$	SHIFT x^2(√‾)2 + SHIFT x^2(√‾)5 EXE
$(-3)^2=(-3)\times(-3)=9$	((−) 3) x^2 EXE
$8!\ (=1\times2\times3\times\ldots\times8)=40320$	8 OPTN F6(▷) F3(PROB) F1(x!) EXE
What is the integer part of – 3.5? – 3	OPTN F6(▷) F4(NUM) F2(Int) (−)3.5 EXE

Random Number Generation (RAND)

• Random Number Generation (0 to 1) (Ran#, RanList#)

Ran# and RanList# generate 10 digit random numbers randomly or sequentially from 0 to 1. Ran# returns a single random number, while RanList# returns multiple random numbers in list form. The following shows the syntaxes of Ran# and RanList#.

Ran# [a]	$1 \leqq a \leqq 9$
RanList# (n [,a])	$1 \leqq n \leqq 999$

- n is the number of trials. RanList# generates the number of random numbers that corresponds to n and displays them on the ListAns screen. A value must be input for n.
- "a" is the randomization sequence. Random numbers are returned if nothing is input for "a". Entering an integer of 1 through 9 for a will return the corresponding sequential random number.
- Executing the function Ran# 0 initializes the sequences of both Ran# and RanList#. The sequence also is initialized when a sequential random number is generated with a different sequence of the previous execution using Ran# or RanList#, or when generating a random number.

Ran# Examples

Example	Operation
Ran# (Generates a random number.)	OPTN F6(▷) F3(PROB) F4(RAND) F1(Ran#) EXE
(Each press of EXE generates a new random number.)	EXE EXE
Ran# 1 (Generates the first random number in sequence 1.)	OPTN F6(▷) F3(PROB) F4(RAND) F1(Ran#)1 EXE
(Generates the second random number in sequence 1.)	EXE
Ran# 0 (Initializes the sequence.)	F1(Ran#)0 EXE

Ran# 1 (Generates the first random number in sequence 1.)	F1 (Ran#) 1 EXE

RanList# Examples

Example	Operation
RanList# (4) (Generates four random numbers and displays the result on the ListAns screen.)	OPTN F6 (▷) F3 (PROB) F4 (RAND) F5 (List) 4) EXE
RanList# (3, 1) (Generates from the first to the third random numbers of sequence 1 and displays the result on the ListAns screen.)	EXIT OPTN F6 (▷) F3 (PROB) F4 (RAND) F5 (List) 3 , 1) EXE
(Next, generates from the fourth to the sixth random number of sequence 1 and displays the result on the ListAns screen.)	EXIT EXE
Ran# 0 (Initializes the sequence.)	EXIT F1 (Ran#) 0 EXE
RanList# (3, 1) (Re-generates from the first to the third random numbers of sequence 1 and displays the result on the ListAns screen.)	F5 (List) 3 , 1) EXE

• Random Integer Generation (RanInt#)

RanInt# generates random integers that fall between two specified integers.

RanInt# (A, B [,n]) $A < B$ $|A|,|B| < 1\text{E}10$ $B - A < 1\text{E}10$ $1 \leqq n \leqq 999$

- A is the start value and B is the end value. Omitting a value for n returns a generated random number as-is. Specifying a value for n returns the specified number of random values in list form.

Example	Operation
RanInt# (1, 5) (Generates one random integer from 1 and 5.)	OPTN F6 (▷) F3 (PROB) F4 (RAND) F2 (Int) 1 , 5) EXE
RanInt# (1, 10, 5) (Generates five random integers from 1 to 10 and displays the result on the ListAns screen.)	OPTN F6 (▷) F3 (PROB) F4 (RAND) F2 (Int) 1 , 10 , 5) EXE

• Random Number Generation in Accordance with Normal Distribution (RanNorm#)

This function generates a 10-digit random number in accordance with normal distribution based on a specified mean μ and standard deviation σ values.

RanNorm# (σ, μ [,n]) $\sigma > 0$ $1 \leqq n \leqq 999$

- Omitting a value for n returns a generated random number as-is. Specifying a value for n returns the specified number of random values in list form.

Example	Operation
RanNorm# (8, 68) (Randomly produces a body length value obtained in accordance with the normal distribution of a group of infants less than one year old with a mean body length of 68cm and standard deviation of 8.)	OPTN F6(▷)F3(PROB)F4(RAND)F3(Norm) **8 , 68)** EXE
RanNorm# (8, 68, 5) (Randomly produces the body lengths of five infants in the above example, and displays them in a list.)	OPTN F6(▷)F3(PROB)F4(RAND)F3(Norm) **8 , 68 , 5)** EXE

• Random Number Generation in Accordance with Binomial Distribution (RanBin#)

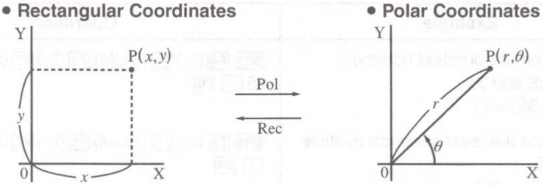
This function generates random integers in accordance with binomial distribution based on values specified for the number of trials n and probability p.

RanBin# (n, p [,m]) $1 \leqq n \leqq 100000$ $1 \leqq m \leqq 999$ $0 \leqq p \leqq 1$

- Omitting a value for m returns a generated random number as-is. Specifying a value for m returns the specified number of random values in list form.

Example	Operation
RanBin# (5, 0.5) (Randomly produces the number of heads that can be expected in accordance with binomial distribution for five coin tosses where the probability of heads is 0.5.)	OPTN F6(▷)F3(PROB)F4(RAND)F4(Bin) **5 , 0.5)** EXE
RanBin# (5, 0.5, 3) (Performs the same coin toss sequence described above three times and displays the results in a list.)	OPTN F6(▷)F3(PROB)F4(RAND)F4(Bin) **5 , 0.5 , 3)** EXE

Coordinate Conversion



- **Rectangular Coordinates**
- **Polar Coordinates**

- With polar coordinates, θ can be calculated and displayed within a range of –180°< $\theta \leqq$ 180° (radians and grads have same range).
- Be sure to specify Comp for Mode in the Setup screen.

Example	Operation
Calculate r and θ° when x = 14 and y = 20.7 1 $\boxed{24.989}$ → 24.98979792 (r) 2 55.928 → 55.92839019 (θ)	SHIFT MENU (SET UP) ▼ ▼ ▼ ▼ ▼ F1 (Deg) EXIT OPTN F6 (▷) F5 (ANGL) F6 (▷) F1 (Pol(**14** , **20.7**) EXE EXIT
Calculate x and y when r = 25 and θ = 56° 1 $\boxed{13.979}$ → 13.97982259 (x) 2 20.725 → 20.72593931 (y)	F2 (Rec(**25** , **56**) EXE

Permutation and Combination

• Permutation

$$nPr = \frac{n!}{(n-r)!}$$

• Combination

$$nCr = \frac{n!}{r!\,(n-r)!}$$

- Be sure to specify Comp for Mode in the Setup screen.

Example 1 **To calculate the possible number of different arrangements using 4 items selected from among 10 items**

Formula	Operation
$_{10}P_4$ = 5040	**10** OPTN F6 (▷) F3 (PROB) F2 ($_nP_r$) **4** EXE

Example 2 **To calculate the possible number of different combinations of 4 items that can be selected from among 10 items**

Formula	Operation
$_{10}C_4$ = 210	**10** OPTN F6 (▷) F3 (PROB) F3 ($_nC_r$) **4** EXE

■ Greatest Common Divisor (GCD), Least Common Multiple (LCM)

Example	Operation
To determine the greatest common divisor of 28 and 35 (GCD (28, 35) = 7)	OPTN F6 (▷) F4 (NUM) F6 (▷) F2 (GCD) **28** , **35**) EXE
To determine the least common multiple of 9 and 15 (LCM (9, 15) = 45)	OPTN F6 (▷) F4 (NUM) F6 (▷) F3 (LCM) **9** , **15**) EXE

■ Division Remainder (MOD), Remainder of Exponential Division (MOD Exp)

Example	Operation
To determine the remainder when 137 is divided by 7 (MOD (137, 7) = 4)	OPTN F6 (▷) F4 (NUM) F6 (▷) F4 (MOD) **137** , **7**) EXE
To determine the remainder when 5^3 is divided by 3 (MOD • E (5, 3, 3) = 2)	OPTN F6 (▷) F4 (NUM) F6 (▷) F5 (MOD • E) **5** , **3** , **3**) EXE

■ Fractions

- Be sure to specify Comp for Mode in the Setup screen.

Example	Operation
$\frac{2}{5}+3\frac{1}{4}=\frac{73}{20}$	**2** $a\frac{b}{c}$ **5** + **3** $a\frac{b}{c}$ **1** $a\frac{b}{c}$ **4** EXE
= 3.65 (Conversion to decimal)*1	F↔D
$\frac{1}{2578}+\frac{1}{4572}=6.066202547\times10^{-4}$ *2	**1** $a\frac{b}{c}$ **2578** + **1** $a\frac{b}{c}$ **4572** EXE
$\frac{1}{2}\times0.5=0.25$*3	**1** $a\frac{b}{c}$ **2** × **.5** EXE

*1 Fractions can be converted to decimal values and vice versa.

*2 When the total number of characters, including integer, numerator, denominator and delimiter marks exceeds 10, the fraction is automatically displayed in decimal format.

*3 Calculations containing both fractions and decimals are calculated in decimal format.

- Pressing the SHIFT F↔D ($a\frac{b}{c} \leftrightarrow \frac{d}{c}$) key toggles the display fraction between mixed fraction and improper fraction format.

■ Engineering Notation Calculations

Input engineering symbols using the engineering notation menu.

- Be sure to specify Comp for Mode in the Setup screen.

Example	Operation
999k (kilo) + 25k (kilo) = 1.024M (mega)	SHIFT MENU (SET UP) ▲ ▲ F4 (Eng) EXIT **999** OPTN F6 (▷) F6 (▷) F1 (ESYM) F6 (▷) F1 (k) + **25** F1 (k) EXE
9 ÷ 10 = 0.9 = 900m (milli)	**9** ÷ **10** EXE
= 0.9	OPTN F6 (▷) F6 (▷) F1 (ESYM) F6 (▷) F6 (▷) F3 ($\overleftarrow{\text{ENG}}$)*1
= 0.0009k (kilo)	F3 ($\overleftarrow{\text{ENG}}$)*1
= 0.9	F2 (ENG)*2
= 900m	F2 (ENG)*2

*1 Converts the displayed value to the next higher engineering unit, by shifting the decimal point three places to the right.

*2 Converts the displayed value to the next lower engineering unit, by shifting the decimal point three places to the left.

■ Logical Operators (AND, OR, NOT, XOR) [OPTN]-[LOGIC]

The logical operator menu provides a selection of logical operators.

- {**And**}/{**Or**}/{**Not**}/{**Xor**} ... {logical AND}/{logical OR}/{logical NOT}/{logical XOR}
- Be sure to specify Comp for Mode in the Setup screen.

Example **What is the logical AND of A and B when A = 3 and B = 2?**
A AND B = 1

Operation	Display
3 → ALPHA X,θ,T (A) EXE **2** → ALPHA log (B) EXE ALPHA X,θ,T (A) OPTN F6 (▷) F6 (▷) F4 (LOGIC) F1 (And) ALPHA log (B) EXE	**1**

• About Logical Operations

- A logical operation always produces either 0 or 1 as its result.
- The following table shows all of possible results that can be produced by AND, OR and XOR operations.

Value or Expression A	Value or Expression B	A AND B	A OR B	A XOR B
A ≠ 0	B ≠ 0	1	1	0
A ≠ 0	B = 0	0	1	1
A = 0	B ≠ 0	0	1	1
A = 0	B = 0	0	0	0

- The following table shows the results produced by the NOT operation.

Value or Expression A	NOT A
$A \neq 0$	0
$A = 0$	1

5. Numerical Calculations

The following explains the numerical calculation operations included in the function menu displayed when OPTN F4(CALC) is pressed. The following calculations can be performed.

- {**Int÷**}/{**Rmdr**}/{**Simp**} ... {quotient}/{remainder}/{simplification}
- {**Solve**}/{d/dx}/{d^2/dx^2}/{$\int dx$}/{**SolvN**} ... {equality solution}/{differential}/{quadratic differential}/{integration}/{$f(x)$ function solution}
- {**FMin**}/{**FMax**}/{**Σ(**}/{$\mathbf{log_a b}$} ... {minimum value}/{maximum value}/{summation}/{logarithm $\log_a b$}

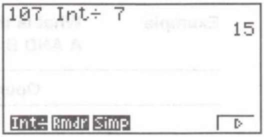
■ Quotient of Integer ÷ Integer

[OPTN]-[CALC]-[Int÷]

The "Int÷" function can be used to determine the quotient when one integer is divided by another integer.

Example **To calculate the quotient of 107 ÷ 7**

AC 1 0 7 OPTN F4(CALC) F6(▷)
F6(▷) F1(Int÷) 7
EXE



107 Int÷ 7
15

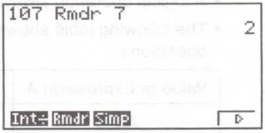
■ Remainder of Integer ÷ Integer

[OPTN]-[CALC]-[Rmdr]

The "Rmdr" function can be used to determine the remainder when one integer is divided by another integer.

Example **To calculate the remainder of 107 ÷ 7**

AC 1 0 7 OPTN F4(CALC) F6(▷)
F6(▷) F2(Rmdr) 7
EXE



107 Rmdr 7
2

■ Simplification [OPTN]-[CALC]-[Simp]

The "▶Simp" function can be used to simplify fractions manually. The following operations can be used to perform simplification when an unsimplified calculation result is on the display.

- {**Simp**} [EXE] ... This function automatically simplifies the displayed calculation result using the smallest prime number available. The prime number used and the simplified result are shown on the display.
- {**Simp**} *n* [EXE] ... This function performs simplification according to the specified divisor *n*.

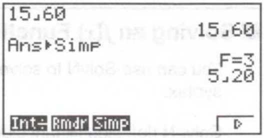
Under initial default settings, this calculator automatically simplifies fraction calculation results before displaying them. Before performing the following examples, use the Setup screen to change the "Simplify" setting from "Auto" to "Manual" (page 1-16).

- When "a+b*i*" or "*r*∠*θ*" is specified for the Setup screen "Complex Mode" setting, fraction calculation results always are simplified before being displayed, even if the "Simplify" setting is "Manual".
- If you want to simplify fractions manually (Simplify: Manual), make sure that the "Real" is selected for the "Complex Mode" setting.

Example 1 **To simplify** $\frac{15}{60}$ $\left(\frac{15}{60}=\frac{5}{20}=\frac{1}{4}\right)$

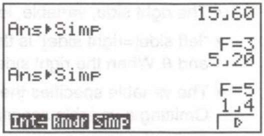
[AC][1][5][a b/c][6][0][EXE]

[OPTN][F4](CALC)[F6](▷)[F6](▷)[F3](Simp)[EXE]



```
15⌟60
                15⌟60
Ans▶Simp
                  F=3
                 5⌟20
```

[F3](Simp)[EXE]



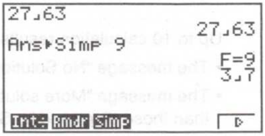
```
                15⌟60
Ans▶Simp
                  F=3
                 5⌟20
Ans▶Simp
                  F=5
                  1⌟4
```

The "F=" value is the divisor.

Example 2 **To simplify** $\frac{27}{63}$ **specifying a divisor of 9** $\left(\frac{27}{63}=\frac{3}{7}\right)$

[AC][2][7][a b/c][6][3][EXE][OPTN][F4](CALC)

[F6](▷)[F6](▷)[F3](Simp)[9][EXE]



```
27⌟63
                27⌟63
Ans▶Simp 9
                  F=9
                  3⌟7
```

- An error occurs if simplification cannot be performed using the specified divisor.
- Executing ▶Simp while a value that cannot be simplified is displayed will return the original value, without displaying "F=".

Solve Calculations [OPTN]-[CALC]-[Solve]

The following is the syntax for using the Solve function in a program.

Solve($f(x)$, n, a, b) (a: lower limit, b: upper limit, n: initial estimated value)

There are two different input methods that can be used for Solve calculations: direct assignment and variable table input.

With the direct assignment method (the one described here), you assign values directly to variables. This type of input is identical to that used with the Solve command used in the **PRGM** mode.

Variable table input is used with the Solve function in the **EQUA** mode. This input method is recommended for most normal Solve function input.

An error (Time Out) occurs when there is no convergence of the solution.

For information about Solve calculations, see page 4-4.

- You cannot use a quadratic differential, Σ, maximum/minimum value or Solve calculation expression inside of any of the above functions.
- Pressing AC during calculation of Solve (while the cursor is not shown on the display) interrupts the calculation.

Solving an $f(x)$ Function [OPTN]-[CALC]-[SolvN]

You can use SolvN to solve an $f(x)$ function using numerical analysis. The following is the input syntax.

SolveN (left side [=right side] [,variable] [, lower limit, upper limit])

- The right side, variable, lower limit and upper limit all can be omitted.
- "left side[=right side]" is the expression to be solved. Supported variables are A through Z, r, and θ. When the right side is omitted, solution is perform using right side = 0.
- The variable specifies the variable within the expression to be solved for (A through Z, r, θ). Omitting a variable specification cause X to be used as the variable.
- The lower limit and upper limit specify the range of the solution. You can input a value or an expression as the range.
- The following functions cannot be used within any of the arguments.
  Solve(, d^2/dx^2, FMin(, FMax(, Σ(

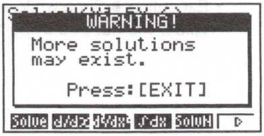
Up to 10 calculation results can be displayed simultaneously in ListAns format.

- The message "No Solution" is displayed if no solution exists.
- The message "More solutions may exist." is displayed when there may be solutions other than those displayed by SolvN.

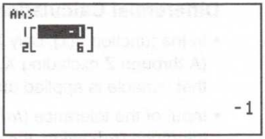
Example **To solve $x^2 - 5x - 6 = 0$**

OPTN F4(CALC) F5(SolvN)

X,θ,T x^2 − 5 X,θ,T − 6) EXE


WARNING!
More solutions may exist.
Press:[EXIT]

$\boxed{\text{EXIT}}$



```
Ans
 1[    -1]
 2[     6]

                  -1
```

■ Differential Calculations **[OPTN]-[CALC]-[*d*/*dx*]**

To perform differential calculations, first display the function analysis menu, and then input the values using the syntax below.

$\boxed{\text{OPTN}}$ $\boxed{\text{F4}}$(CALC) $\boxed{\text{F2}}$(*d*/*dx*) *f*(*x*) $\boxed{,}$ *a* $\boxed{,}$ *tol* $\boxed{)}$

(*a*: point for which you want to determine the derivative, *tol*: tolerance)

$$d/dx\ (\,f(x),\,a) \Rightarrow \frac{d}{dx}\,f(a)$$

The differentiation for this type of calculation is defined as:

$$f'(a) = \lim_{\Delta x \to 0} \frac{f(a+\Delta x) - f(a)}{\Delta x}$$

In this definition, *infinitesimal* is replaced by a *sufficiently small* Δx, with the value in the neighborhood of $f'(a)$ calculated as:

$$f'(a) \fallingdotseq \frac{f(a+\Delta x) - f(a)}{\Delta x}$$

In order to provide the best precision possible, this unit employs central difference to perform differential calculations.

Example **To determine the derivative at point $x = 3$ for the function $y = x^3 + 4x^2 + x - 6$, with a tolerance of "*tol*" = 1E – 5**

Input the function *f*(*x*).

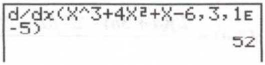
$\boxed{\text{AC}}$ $\boxed{\text{OPTN}}$ $\boxed{\text{F4}}$(CALC) $\boxed{\text{F2}}$(*d*/*dx*) $\boxed{\text{X,θ,T}}$ $\boxed{\wedge}$ $\boxed{3}$ $\boxed{+}$ $\boxed{4}$ $\boxed{\text{X,θ,T}}$ $\boxed{x^2}$ $\boxed{+}$ $\boxed{\text{X,θ,T}}$ $\boxed{-}$ $\boxed{6}$ $\boxed{,}$

Input point $x = a$ for which you want to determine the derivative.

$\boxed{3}$ $\boxed{,}$

Input the tolerance value.

$\boxed{1}$ $\boxed{\text{EXP}}$ $\boxed{(-)}$ $\boxed{5}$ $\boxed{)}$ $\boxed{\text{EXE}}$



```
d/dx(X^3+4X²+X-6,3,1E
-5)
                     52
```

Using Differential Calculation in a Graph Function

- Omitting the tolerance (*tol*) value when using the differential command inside of a graph function simplifies the calculation for drawing the graph. In such a case, precision is sacrificed for the sake of faster drawing. The tolerance value is specified, the graph is drawn with the same precision obtained when you normally perform a differential calculation.
- You can also omit input of the derivative point by using the following format for the differential graph: Y2=*d*/*dx*(Y1). In this case, the value of the X variable is used as the derivative point.

Differential Calculation Precautions

- In the function $f(x)$, only X can be used as a variable in expressions. Other variables (A through Z excluding X, r, θ) are treated as constants, and the value currently assigned to that variable is applied during the calculation.
- Input of the tolerance (*tol*) value and the closing parenthesis can be omitted. If you omit tolerance (*tol*) value, the calculator automatically uses a value for *tol* as 1E–10.
- Specify a tolerance (*tol*) value of 1E–14 or greater. An error (Time Out) occurs whenever no solution that satisfies the tolerance value can be obtained.
- Pressing AC during calculation of a differential (while the cursor is not shown on the display) interrupts the calculation.
- Inaccurate results and errors can be caused by the following:
  - discontinuous points in x values
  - extreme changes in x values
  - inclusion of the local maximum point and local minimum point in x values
  - inclusion of the inflection point in x values
  - inclusion of undifferentiable points in x values
  - differential calculation results approaching zero
- Always use radians (Rad mode) as the angle unit when performing trigonometric differentials.
- You cannot use a differential, quadratic differential, integration, Σ, maximum/minimum value, Solve, RndFix or $\log_a b$ calculation expression inside a differential calculation term.

■ Quadratic Differential Calculations [OPTN]-[CALC]-[d^2/dx^2]

After displaying the function analysis menu, you can input quadratic differentials using the following syntax.

OPTN F4(CALC) F3(d^2/dx^2) $f(x)$, a , tol)

(a: differential coefficient point, *tol*: tolerance)

$$\frac{d^2}{dx^2}(f(x), a) \Rightarrow \frac{d^2}{dx^2} f(a)$$

Quadratic differential calculations produce an approximate differential value using the following second order differential formula, which is based on Newton's polynomial interpretation.

$$f''(a) = \frac{2f(a+3h) - 27f(a+2h) + 270f(a+h) - 490f(a) + 270f(a-h) - 27f(a-2h) + 2f(a-3h)}{180h^2}$$

In this expression, values for "sufficiently small increments of h" are used to obtain a value that approximates $f''(a)$.

Example **To determine the quadratic differential coefficient at the point where $x = 3$ for the function $y = x^3 + 4x^2 + x - 6$**
Here we will use a tolerance tol = 1E – 5

Input the function $f(x)$.

AC OPTN F4(CALC) F3(d^2/dx^2) X,θ,T ∧ 3 + 4 X,θ,T x^2 + X,θ,T − 6 ,

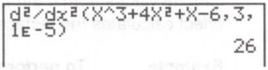
Input 3 as point a, which is the differential coefficient point.

3 ,

Input the tolerance value.

[1] [EXP] [(-)] [5] [)]

[EXE]



```
d²/dx²(X^3+4X²+X-6,3,
1E-5)
                   26
```

Quadratic Differential Calculation Precautions

- In the function *f*(*x*), only X can be used as a variable in expressions. Other variables (A through Z excluding X, *r*, *θ*) are treated as constants, and the value currently assigned to that variable is applied during the calculation.
- Input of the tolerance (*tol*) value and the closing parenthesis can be omitted.
- Specify a tolerance (*tol*) value of 1E–14 or greater. An error (Time Out) occurs whenever no solution that satisfies the tolerance value can be obtained.
- The rules that apply for linear differential also apply when using a quadratic differential calculation for the graph formula (see page 2-21).
- Inaccurate results and errors can be caused by the following:
  - discontinuous points in x values
  - extreme changes in x values
  - inclusion of the local maximum point and local minimum point in x values
  - inclusion of the inflection point in x values
  - inclusion of undifferentiable points in x values
  - differential calculation results approaching zero
- You can interrupt an ongoing quadratic differential calculation by pressing the [AC] key.
- Always use radians (Rad mode) as the angle unit when performing trigonometric quadratic differentials.
- You cannot use a differential, quadratic differential, integration, Σ, maximum/minimum value, Solve, RndFix or $\log_a b$ calculation expression inside of a quadratic differential calculation term.
- With quadratic differential calculation, calculation precision is up to five digits for the mantissa.

■ Integration Calculations

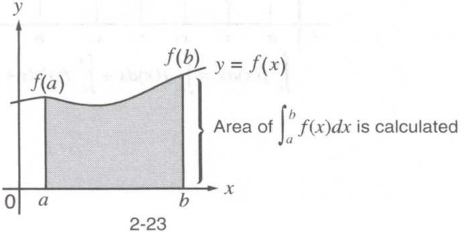
[OPTN]-[CALC]-[∫*dx*]

To perform integration calculations, first display the function analysis menu and then input the values using the syntax below.

[OPTN] [F4] (CALC) [F4] (∫*dx*) *f*(*x*) [,] *a* [,] *b* [,] *tol* [)]

(*a*: start point, *b*: end point, *tol*: tolerance)

$$\int(f(x), a, b, tol) \Rightarrow \int_a^b f(x)dx$$



As shown in the illustration above, integration calculations are performed by calculating integral values from a through b for the function $y = f(x)$ where $a \leqq x \leqq b$, and $f(x) \geqq 0$. This in effect calculates the surface area of the shaded area in the illustration.

Example **To perform the integration calculation for the function shown below, with a tolerance of "*tol*" = 1E – 4**

$$\int_1^5 (2x^2 + 3x + 4)\,dx$$

Input the function $f(x)$.

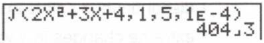
AC OPTN F4 (CALC) F4 (∫dx) 2 X,θ,T x² + 3 X,θ,T + 4 ,

Input the start point and end point.

1 , 5 ,

Input the tolerance value.

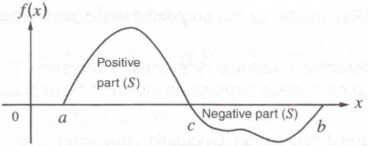
1 EXP (–) 4) EXE



```
∫(2X²+3X+4,1,5,1E-4)
                404⌟3
```

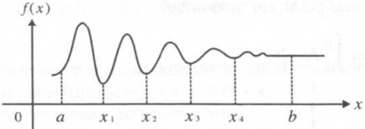
Note the following points to ensure correct integration values.

(1) When cyclical functions for integration values become positive or negative for different divisions, perform the calculation for single cycles, or divide between negative and positive, and then add the results together.



$$\int_a^b f(x)dx = \underbrace{\int_a^c f(x)dx}_{\textit{Positive part (S)}} + \underbrace{(-\int_c^b f(x)dx)}_{\textit{Negative part (S)}}$$

(2) When minute fluctuations in integration divisions produce large fluctuations in integration values, calculate the integration divisions separately (divide the large fluctuation areas into smaller divisions), and then add the results together.



$$\int_a^b f(x)dx = \int_a^{x_1} f(x)dx + \int_{x_1}^{x_2} f(x)dx + ... + \int_{x_4}^{b} f(x)dx$$

- Pressing AC during calculation of an integral (while the cursor is not shown on the display) interrupts the calculation.
- Always use radians (Rad mode) as the angle unit when performing trigonometric integrations.
- An error (Time Out) occurs whenever no solution that satisfies the tolerance value can be obtained.

Integration Calculation Precautions

- In the function *f*(*x*), only X can be used as a variable in expressions. Other variables (A through Z excluding X, *r*, *θ*) are treated as constants, and the value currently assigned to that variable is applied during the calculation.
- Input of "*tol*" and closing parenthesis can be omitted. If you omit "*tol*," the calculator automatically uses a default value of 1E–5.
- Integration calculations can take a long time to complete.
- You cannot use a differential, quadratic differential, integration, Σ, maximum/minimum value, Solve, RndFix or $\log_a b$ calculation expression inside of an integration calculation term.

■ Σ Calculations [OPTN]-[CALC]-[Σ(]

To perform Σ calculations, first display the function analysis menu, and then input the values using the syntax below.

OPTN F4(CALC) F6(▷) F3(Σ( ) a_k , k , α , β , n)

$$\sum(a_k, k, \alpha, \beta, n) = \sum_{k=\alpha}^{\beta} a_k = a_\alpha + a_{\alpha+1} + \ldots\ldots.. + a_\beta$$

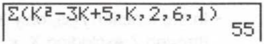
(*n*: distance between partitions)

Example **To calculate the following:**

$$\sum_{k=2}^{6}(k^2 - 3k + 5)$$

Use $n = 1$ as the distance between partitions.

AC OPTN F4(CALC) F6(▷) F3(Σ( ) ALPHA , (K)
x² − 3 ALPHA , (K) + 5 ,
ALPHA , (K) , 2 , 6 , 1) EXE



```
Σ(K²-3K+5,K,2,6,1)
                        55
```

Σ Calculation Precautions

- The value of the specified variable changes during a Σ calculation. Be sure to keep separate written records of the specified variable values you might need later before you perform the calculation.
- You can use only one variable in the function for input sequence a_k.
- Input integers only for the initial term (α) of sequence a_k and last term (β) of sequence a_k.
- Input of n and the closing parentheses can be omitted. If you omit n, the calculator automatically uses $n = 1$.
- Make sure that the value used as the final term β is greater than the value used as the initial term α. Otherwise, an error will occur.

- To interrupt an ongoing Σ calculation (indicated when the cursor is not on the display), press the AC key.
- You cannot use a differential, quadratic differential, integration, Σ, maximum/minimum value, Solve, RndFix or $\log_a b$ calculation expression inside of a Σ calculation term.

■ Maximum/Minimum Value Calculations [OPTN]-[CALC]-[FMin]/[FMax]

After displaying the function analysis menu, you can input maximum/minimum calculations using the formats below, and solve for the maximum and minimum of a function within interval $a \leqq x \leqq b$.

• Minimum Value

OPTN F4 (CALC) F6 (▷) F1 (FMin) $f(x)$, a , b , n)

(a: start point of interval, b: end point of interval, n: precision (n = 1 to 9))

• Maximum Value

OPTN F4 (CALC) F6 (▷) F2 (FMax) $f(x)$, a , b , n)

(a: start point of interval, b: end point of interval, n: precision (n = 1 to 9))

Example **To determine the minimum value for the interval defined by start point $a = 0$ and end point $b = 3$, with a precision of $n = 6$ for the function $y = x^2 - 4x + 9$**

Input $f(x)$.

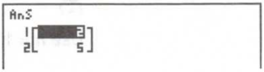
AC OPTN F4 (CALC) F6 (▷) F1 (FMin) X,θ,T x^2 − 4 X,θ,T + 9 ,

Input the interval $a = 0$, $b = 3$.

0 , 3 ,

Input the precision $n = 6$.

6) EXE



```
Ans
 1[      2]
 2[      5]
```

- In the function $f(x)$, only X can be used as a variable in expressions. Other variables (A through Z excluding X, r, θ) are treated as constants, and the value currently assigned to that variable is applied during the calculation.
- Input of n and the closing parenthesis can be omitted.
- Discontinuous points or sections with drastic fluctuation can adversely affect precision or even cause an error.
- Inputting a larger value for n increases the precision of the calculation, but it also increases the amount of time required to perform the calculation.
- The value you input for the end point of the interval (b) must be greater than the value you input for the start point (a). Otherwise an error occurs.
- You can interrupt an ongoing maximum/minimum calculation by pressing the AC key.
- You can input an integer in the range of 1 to 9 for the value of n. Using any value outside this range causes an error.

- You cannot use a differential, quadratic differential, integration, Σ, maximum/minimum value, Solve, RndFix or $\log_a b$ calculation expression inside of a maximum/minimum calculation term.

6. Complex Number Calculations

You can perform addition, subtraction, multiplication, division, parentheses calculations, function calculations, and memory calculations with complex numbers just as you do with the manual calculations described on pages 2-1 to 2-12.

You can select the complex number calculation mode by changing the Complex Mode item on the Setup screen to one of the following settings.

- {**Real**} ... Calculation in the real number range only*1
- {$a+bi$} ... Performs complex number calculation and displays results in rectangular form
- {$r\angle\theta$} ... Performs complex number calculation and displays results in polar form*2

*1 When there is an imaginary number in the argument, however, complex number calculation is performed and the result is displayed using rectangular form.

Examples:

ln $2i$ = 0.6931471806 + 1.570796327i

ln $2i$ + ln (– 2) = (Non-Real ERROR)

*2 The display range of θ depends on the angle unit set for the Angle item on the Setup screen.

- Deg ... $-180 < \theta \leqq 180$
- Rad ... $-\pi < \theta \leqq \pi$
- Gra ... $-200 < \theta \leqq 200$

Press OPTN F3 (CPLX) to display the complex calculation number menu, which contains the following items.

- {i} ... {imaginary unit i input}
- {**Abs**}/{**Arg**} ... obtains {absolute value}/{argument}
- {**Conj**} ... {obtains conjugate}
- {**ReP**}/{**ImP**} ... {real}/{imaginary} part extraction
- {$\blacktriangleright r\angle\theta$}/{$\blacktriangleright a+bi$} ... converts the result to {polar}/{rectangular} form

- You can also use SHIFT 0 (i) in place of OPTN F3 (CPLX) F1 (i).
- Solutions obtained by the Real, $a+bi$ and $r\angle\theta$ modes are different for power root (x^y) calculations when $x < 0$ and $y = m/n$ when n is an odd number.

  Example: $3\,{}^{x}\!\sqrt{\ }\,(-8) = -2$ (Real)
  $= 1 + 1.732050808i$ ($a+bi$)
  $= 2\angle 60$ ($r\angle\theta$)

- To input the " $\angle$ " operator into the polar coordinate expression ($r\angle\theta$), press SHIFT X,θ,T ($\angle$).

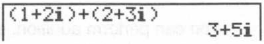
■ Arithmetic Operations

[OPTN]-[CPLX]-[*i*]

Arithmetic operations are the same as those you use for manual calculations. You can even use parentheses and memory.

Example **(1 + 2*i*) + (2 + 3*i*)**

AC OPTN F3(CPLX)
(1 + 2 F1(*i*))
+ (2 + 3 F1(*i*)) EXE

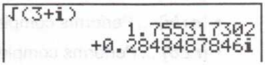


(1+2i)+(2+3i)
3+5i

■ Reciprocals, Square Roots, and Squares

Example $\sqrt{(3+i)}$

AC OPTN F3(CPLX)
SHIFT x^2(√) (3 + F1(*i*)) EXE

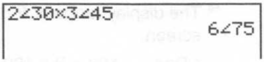


√(3+i)
1.755317302
+0.2848487846i

■ Complex Number Format Using Polar Form

Example **2∠30 × 3∠45 = 6∠75**

SHIFT MENU(SET UP) ▼ ▼ ▼ ▼ ▼
F1(Deg) ▼ F3($r\angle\theta$) EXIT
AC 2 SHIFT X,θ,T(∠) 3 0 × 3
SHIFT X,θ,T(∠) 4 5 EXE



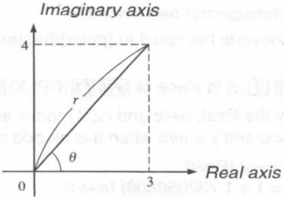
2∠30×3∠45
6∠75

■ Absolute Value and Argument

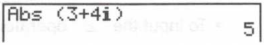
[OPTN]-[CPLX]-[Abs]/[Arg]

The unit regards a complex number in the form *a* + *bi* as a coordinate on a Gaussian plane, and calculates absolute value | Z | and argument (arg).

Example **To calculate absolute value (*r*) and argument (*θ*) for the complex number 3 + 4*i*, with the angle unit set for degrees**



AC OPTN F3(CPLX) F2(Abs)
(3 + 4 F1(*i*)) EXE



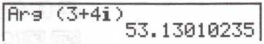
Abs (3+4i)
5

(Calculation of absolute value)

AC OPTN F3 (CPLX) F3 (Arg)

(3 + 4 F1 (*i*)) EXE

(Calculation of argument)



```
Arg (3+4i)
           53.13010235
```

- The result of the argument calculation differs in accordance with the current angle unit setting (degrees, radians, grads).

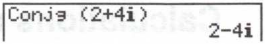
■ Conjugate Complex Numbers [OPTN]-[CPLX]-[Conj]

A complex number of the form $a + bi$ becomes a conjugate complex number of the form $a - bi$.

Example **To calculate the conjugate complex number for the complex number 2 + 4*i***

AC OPTN F3 (CPLX) F4 (Conj)

(2 + 4 F1 (*i*)) EXE



```
Conjg (2+4i)
                  2-4i
```

■ Extraction of Real and Imaginary Parts [OPTN]-[CPLX]-[ReP]/[ImP]

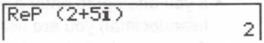
Use the following procedure to extract the real part a and the imaginary part b from a complex number of the form $a + bi$.

Example **To extract the real and imaginary parts of the complex number 2 + 5*i***

AC OPTN F3 (CPLX) F6 (▷) F1 (ReP)

(2 + 5 F6 (▷) F1 (*i*)) EXE

(Real part extraction)

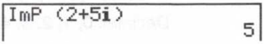


```
ReP (2+5i)
                     2
```

AC OPTN F3 (CPLX) F6 (▷) F2 (ImP)

(2 + 5 F6 (▷) F1 (*i*)) EXE

(Imaginary part extraction)



```
ImP (2+5i)
                     5
```

■ Polar and Rectangular Form Transformation [OPTN]-[CPLX]-[►$r\angle\theta$]/[►$a+bi$]

Use the following procedure to transform a complex number displayed in rectangular form to polar form, and vice versa.

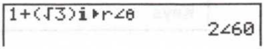
Example **To transform the rectangular form of complex number 1 + $\sqrt{3}\,i$ to its polar form**

SHIFT MENU (SET UP) ▼ ▼ ▼ ▼ ▼

F1 (Deg) ▼ F2 (a+bi) EXIT

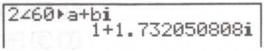
AC 1 + (SHIFT x^2 (√) 3)

OPTN F3 (CPLX) F1 (*i*) F6 (▷) F3 (►$r\angle\theta$) EXE



```
1+(√3)i▸r∠θ
                  2∠60
```

[AC] [2] [SHIFT] [X,θ,T](∠) [6] [0]
[OPTN] [F3](CPLX) [F6](▷) [F4](►a+bi) [EXE]



```
2∠60▸a+bi
      1+1.732050808i
```

- The input/output range of complex numbers is normally 10 digits for the mantissa and two digits for the exponent.
- When a complex number has more than 21 digits, the real part and imaginary part are displayed on separate lines.
- The following functions can be used with complex numbers.
  $\sqrt{\ }$, x^2, x^{-1}, ^(x^y), $\sqrt[3]{\ }$, $\sqrt[x]{\ }$, ln, log, log$_a$b, 10^x, e^x, Int, Frac, Rnd, Intg, RndFix(, Fix, Sci, ENG, $\overleftarrow{\text{ENG}}$, ° ' ", $\overleftarrow{\text{° ' "}}$, a^b/c, d/c

7. Binary, Octal, Decimal, and Hexadecimal Calculations with Integers

You can use the **RUN • MAT** mode and binary, octal, decimal, and hexadecimal settings to perform calculations that involve binary, octal, decimal and hexadecimal values. You can also convert between number systems and perform bitwise operations.

- You cannot use scientific functions in binary, octal, decimal, and hexadecimal calculations.
- You can use only integers in binary, octal, decimal, and hexadecimal calculations, which means that fractional values are not allowed. If you input a value that includes a decimal part, the calculator automatically cuts off the decimal part.
- If you attempt to enter a value that is invalid for the number system (binary, octal, decimal, hexadecimal) you are using, the calculator displays an error message. The following shows the numerals that can be used in each number system.

  Binary: 0, 1

  Octal: 0, 1, 2, 3, 4, 5, 6, 7

  Decimal: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9

  Hexadecimal: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F
- Negative binary, octal, and hexadecimal values are produced using the two's complement of the original value.
- The following are the display capacities for each of the number systems.

Number System	Binary	Octal	Decimal	Hexadecimal
Display Capacity	16 digits	11 digits	10 digits	8 digits

- The alphabetic characters used in the hexadecimal number appear differently on the display to distinguish them from text characters.

Normal Text	A	B	C	D	E	F
Hexadecimal Values	𝔸	𝔹	ℂ	𝔻	𝔼	𝔽
Keys	[X,θ,T]	[log]	[ln]	[sin]	[cos]	[tan]

- The following are the calculation ranges for each of the number systems.

  Binary Values

  Positive: $0 \leqq x \leqq 111111111111111$

  Negative: $1000000000000000 \leqq x \leqq 1111111111111111$

  Octal Values

  Positive: $0 \leqq x \leqq 17777777777$

  Negative: $20000000000 \leqq x \leqq 37777777777$

  Decimal Values

  Positive: $0 \leqq x \leqq 2147483647$

  Negative: $-2147483648 \leqq x \leqq -1$

  Hexadecimal Values

  Positive: $0 \leqq x \leqq$ 7FFFFFFF

  Negative: $80000000 \leqq x \leqq$ FFFFFFFF

• To perform a binary, octal, decimal, or hexadecimal calculation

[SET UP]-[Mode]-[Dec]/[Hex]/[Bin]/[Oct]

1. In the Main Menu, select **RUN • MAT**.
2. Press SHIFT MENU (SET UP). Move the highlighting to "Mode", and then specify the default number system by pressing F2 (Dec), F3 (Hex), F4 (Bin), or F5 (Oct) for the Mode setting.
3. Press EXIT to change to the screen for calculation input. This causes a function menu with the following items to appear.
   - {**d~o**}/{**LOG**}/{**DISP**} ... {number system specification}/{bitwise operation}/{decimal/hexadecimal/binary/octal conversion} menu

■ Selecting a Number System

You can specify decimal, hexadecimal, binary, or octal as the default number system using the Setup screen.

• To specify a number system for an input value

You can specify a number system for each individual value you input. Press F1 (d~o) to display a menu of number system symbols. Press the function key that corresponds to the symbol you want to select and then input the value.

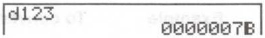
- {**d**}/{**h**}/{**b**}/{**o**} ... {decimal}/{hexadecimal}/{binary}/{octal}

• To input values of mixed number systems

Example **To input 123_{10}, when the default number system is hexadecimal**

SHIFT MENU (SET UP)
Move the highlighting to "Mode", and then press F3 (Hex) EXIT.

AC F1 (d~o) F1 (d) 1 2 3 EXE



```
d123
                0000007B
```

Negative Values and Bitwise Operations

Press F2(LOG) to display a menu of negation and bitwise operators.

- {**Neg**} ... {negation}*1
- {**Not**}/{**and**}/{**or**}/{**xor**}/{**xnor**} ... {NOT}*2/{AND}/{OR}/{XOR}/{XNOR}*3

*1 two's complement

*2 one's complement (bitwise complement)

*3 bitwise AND, bitwise OR, bitwise XOR, bitwise XNOR

• Negative Values

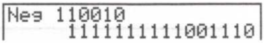
Example **To determine the negative of 110010_2**

SHIFT MENU(SET UP)

Move the highlighting to "Mode", and then press F4(Bin) EXIT.

AC F2(LOG) F1(Neg)

1 1 0 0 1 0 EXE



```
Neg 110010
  1111111111001110
```

- Negative binary, octal, and hexadecimal values are produced by taking the binary two's complement and then returning the result to the original number base. With the decimal number base, negative values are displayed with a minus sign.

• Bitwise Operations

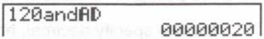
Example **To input and execute "120_{16} and AD_{16}"**

SHIFT MENU(SET UP)

Move the highlighting to "Mode", and then press F3(Hex) EXIT.

AC 1 2 0 F2(LOG)

F3(and) A D EXE



```
120andAD
          00000020
```

Number System Transformation

Press F3(DISP) to display a menu of number system transformation functions.

- {**►Dec**}/{**►Hex**}/{**►Bin**}/{**►Oct**} ... transformation of displayed value to its {decimal}/{hexadecimal}/{binary}/{octal} equivalent

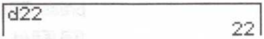
• To convert a displayed value from one number system to another

Example **To convert 22_{10} (default number system) to its binary or octal value**

AC SHIFT MENU(SET UP)

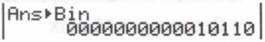
Move the highlighting to "Mode", and then press F2(Dec) EXIT.

F1(d~o) F1(d) 2 2 EXE



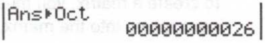
```
d22
                22
```

EXIT F3(DISP) F3(▶Bin) EXE



```
Ans▶Bin
        0000000000010110
```

F4(▶Oct) EXE



```
Ans▶Oct
             00000000026
```

8. Matrix Calculations

From the Main Menu, enter the **RUN • MAT** mode, and press F1(▶MAT) to perform Matrix calculations.

26 matrix memories (Mat A through Mat Z) plus a Matrix Answer Memory (MatAns), make it possible to perform the following matrix operations.

- Addition, subtraction, multiplication, division
- Scalar multiplication calculations
- Determinant calculations
- Matrix transposition
- Matrix inversion
- Matrix squaring
- Raising a matrix to a specific power
- Absolute value, integer part extraction, fractional part extraction, maximum integer calculations
- Inputting complex numbers in matrix elements and using complex number related functions
- Matrix modification using matrix commands

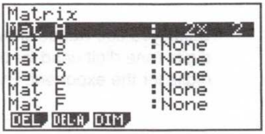
The maximum number of rows that can be specified for a matrix is 999, and the maximum number of columns is 999.

About Matrix Answer Memory (MatAns)

- The calculator automatically stores matrix calculation results in Matrix Answer Memory. Note the following points about Matrix Answer Memory.
- Whenever you perform a matrix calculation, the current Matrix Answer Memory contents are replaced by the new result. The previous contents are deleted and cannot be recovered.
- Inputting values into a matrix does not affect Matrix Answer Memory contents.

■ Inputting and Editing Matrices

Pressing F1(▶MAT) displays the Matrix Editor screen. Use the Matrix Editor to input and edit matrices.



```
Matrix
Mat A       :  2× 2
Mat B       :None
Mat C       :None
Mat D       :None
Mat E       :None
Mat F       :None
DEL DEL·A DIM
```

$m \times n$ … m (row) × n (column) matrix

None… no matrix preset

- {**DEL**}/{**DEL·A**} ... deletes {a specific matrix}/{all matrices}
- {**DIM**} ... {specifies the matrix dimensions (number of cells)}

• Creating a Matrix

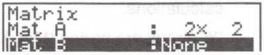
To create a matrix, you must first define its dimensions (size) in the Matrix Editor. Then you can input values into the matrix.

• To specify the dimensions (size) of a matrix

Example **To create a 2-row × 3-column matrix in the area named Mat B**

Highlight Mat B.

▼



```
Matrix
Mat A          :  2×  2
Mat B          :None
```

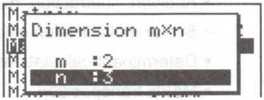
F3 (DIM) (This step can be omitted.)

Specify the number of rows.

2 EXE

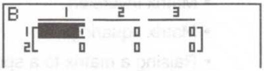
Specify the number of columns.

3 EXE



```
Dimension m×n

 m  :2
 n  :3
```

EXE



```
B     1       2       3
1[          0       0       0]
2[          0       0       0]
```

- All of the cells of a new matrix contain the value 0.
- Changing the dimensions of a matrix deletes its current contents.
- If "Memory ERROR" remains next to the matrix area name after you input the dimensions, it means there is not enough free memory to create the matrix you want.

• To input cell values

Example **To input the following data into Matrix B:**

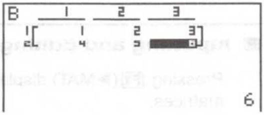
$$\begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \end{bmatrix}$$

The following operation is a continuation of the example calculation on the previous page.

1 EXE 2 EXE 3 EXE

4 EXE 5 EXE 6 EXE

(Data is input into the highlighted cell. Each time you press EXE, the highlighting moves to the next cell to the right.)



```
B     1       2       3
1[          1       2       3]
2[          4       5       0]

                              6
```

- Displayed cell values show positive integers up to six digits, and negative integers up to five digits (one digit used for the negative sign). Exponential values are shown with up to two digits for the exponent. Fractional values are not displayed.

• Deleting Matrices

You can delete either a specific matrix or all matrices in memory.

• To delete a specific matrix

1. While the Matrix Editor is on the display, use ▲ and ▼ to highlight the matrix you want to delete.
2. Press F1(DEL).
3. Press F1(Yes) to delete the matrix or F6(No) to abort the operation without deleting anything.

• To delete all matrices

1. While the Matrix Editor is on the display, press F2(DEL•A).
2. Press F1(Yes) to delete all matrices in memory or F6(No) to abort the operation without deleting anything.

■ Matrix Cell Operations

Use the following procedure to prepare a matrix for cell operations.

1. While the Matrix Editor is on the display, use ▲ and ▼ to highlight the name of the matrix you want to use.
   You can jump to a specific matrix by inputting the letter that corresponds to the matrix name. Inputting ALPHA 8(N), for example, jumps to Mat N.
   Pressing SHIFT (-)(Ans) jumps to the matrix current memory.
2. Press EXE and the function menu with the following items appears.
   - {**R-OP**} ... {row operation menu}
   - {**ROW**}
     - {**DEL**}/{**INS**}/{**ADD**} ... row {delete}/{insert}/{add}
   - {**COL**}
     - {**DEL**}/{**INS**}/{**ADD**} ... column {delete}/{insert}/{add}
   - {**EDIT**} ... {cell editing screen}

All of the following examples use Matrix A.

• Row Calculations

The following menu appears whenever you press F1(R-OP) while a recalled matrix is on the display.

- {**Swap**} ... {row swap}
- {×**Rw**} ... {product of specified row and scalar}
- {×**Rw+**} ... {addition of one row and the product of a specified row with a scalar}
- {**Rw+**} ... {addition of specified row to another row}

• To swap two rows

Example **To swap rows two and three of the following matrix:**

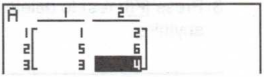
All of the operation examples are performed using the following matrix.

$$\textbf{Matrix A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix}$$

F1(R-OP) F1(Swap)

Input the number of the rows you want to swap.

2 EXE 3 EXE EXE



A	1	2
1	1	2
2	5	6
3	3	4

• To calculate the scalar multiplication of a row

Example **To calculate the product of row 2 and the scalar 4**

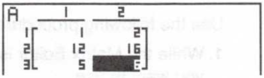
F1(R-OP) F2(×Rw)

Input multiplier value.*

4 EXE

Specify row number.

2 EXE EXE



A	1	2
1	1	2
2	12	16
3	5	6

* A complex number also can be input as multiplier value (k).

• To calculate the scalar multiplication of a row and add the result to another row

Example **To calculate the product of row 2 and the scalar 4, then add the result to row 3**

F1(R-OP) F3(×Rw+)

Input multiplier value.*

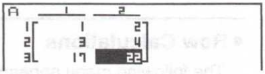
4 EXE

Specify number of row whose product should be calculated.

2 EXE

Specify number of row where result should be added.

3 EXE EXE



A	1	2
1	1	2
2	3	4
3	17	22

* A complex number also can be input as multiplier value (k).

• To add two rows together

Example **To add row 2 to row 3**

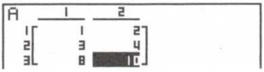
F1(R-OP) F4(Rw+)

Specify number of row to be added.

2 EXE

Specify number of row to be added to.

3 EXE EXE



A	1	2
1	1	2
2	3	4
3	8	10

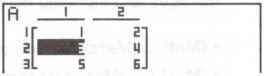
• Row Operations

- {**DEL**} ... {delete row}
- {**INS**} ... {insert row}
- {**ADD**} ... {add row}

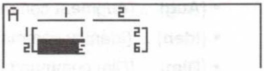
• To delete a row

Example **To delete row 2**

F2(ROW)▼


A
1
2
1
2
3
1
2
4
5
6

F1(DEL)

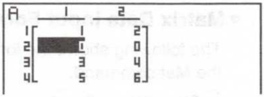


• To insert a row

Example **To insert a new row between rows one and two**

F2(ROW)▼

F2(INS)

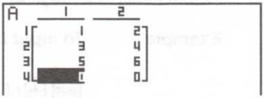

A
1
2
1
2
3
4
1
2
0
3
4
5
6

• To add a row

Example **To add a new row below row 3**

F2(ROW)▼▼

F3(ADD)


A
1
2
1
2
3
4
1
2
3
4
5
6
0

• Column Operations

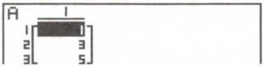
- {**DEL**} ... {delete column}
- {**INS**} ... {insert column}
- {**ADD**} ... {add column}

• To delete a column

Example **To delete column 2**

F3(COL)▶

F1(DEL)



■ Modifying Matrices Using Matrix Commands [OPTN]-[MAT]

• To display the matrix commands

1. From the Main Menu, enter the **RUN • MAT** mode.
2. Press [OPTN] to display the option menu.
3. Press [F2] (MAT) to display the matrix command menu.

The following describes only the matrix command menu items that are used for creating matrices and inputting matrix data.

- {**Mat**} ... {Mat command (matrix specification)}
- {**M→L**} ... {Mat→List command (assign contents of selected column to list file)}
- {**Aug**} ... {Augment command (link two matrices)}
- {**Iden**} ... {Identity command (identity matrix input)}
- {**Dim**} ... {Dim command (dimension check)}
- {**Fill**} ... {Fill command (identical cell values)}

- You can also use [SHIFT] [2] (Mat) in place of [OPTN] [F2] (MAT) [F1] (Mat).

• Matrix Data Input Format [OPTN]-[MAT]-[Mat]

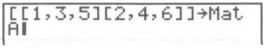
The following shows the format you should use when inputting data to create a matrix using the Mat command.

$$\begin{bmatrix} a_{11} & a_{12} \ \dots & a_{1n} \\ a_{21} & a_{22} \ \dots & a_{2n} \\ \vdots & \vdots & \vdots \\ a_{m1} & a_{m2} \ \dots & a_{mn} \end{bmatrix} = [\,[a_{11}, a_{12}, \dots, a_{1n}]\ [a_{21}, a_{22}, \dots, a_{2n}] \ \dots.\ [a_{m1}, a_{m2}, \dots, a_{mn}]\,]$$

→ Mat [letter A through Z]

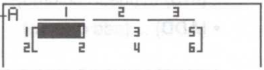
Example **To input the following data as Matrix A:** $\begin{bmatrix} 1 & 3 & 5 \\ 2 & 4 & 6 \end{bmatrix}$

[SHIFT] [+] ([ ) [SHIFT] [+] ([ ) [1] [,] [3] [,] [5]
[SHIFT] [−] ( ]) [SHIFT] [+] ([ ) [2] [•] [4] [•] [6]
[SHIFT] [−] ( ]) [SHIFT] [−] ( ]) [→] [OPTN] [F2] (MAT)
[F1] (Mat) [ALPHA] [X,θ,T] (A)



```
[[1,3,5][2,4,6]]→Mat
A▌
```

[EXE]


Matrix name

- The maximum value of both m and n is 999.
- An error occurs if memory becomes full as you are inputting data.
- You can also use the above format inside a program that inputs matrix data.

• To input an identity matrix

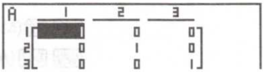
[OPTN]-[MAT]-[Iden]

Use the Identity command to create an identity matrix.

Example **To create a 3 × 3 identity matrix as Matrix A**

OPTN F2 (MAT) F6 (▷) F1 (Iden)
3 → F6 (▷) F1 (Mat) ALPHA X,θ,T (A) EXE

Number of rows/columns



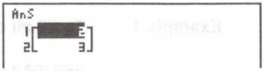
• To check the dimensions of a matrix

[OPTN]-[MAT]-[Dim]

Use the Dim command to check the dimensions of an existing matrix.

Example 1 **To check the dimensions of Matrix A**

OPTN F2 (MAT) F6 (▷) F2 (Dim)
F6 (▷) F1 (Mat) ALPHA X,θ,T (A) EXE

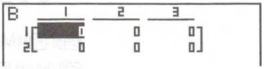


The display shows that Matrix A consists of two rows and three columns.
Since the result of the Dim command is list type data, it is stored in ListAns Memory.

You can also use {Dim} to specify the dimensions of the matrix.

Example 2 **To specify dimensions of 2 rows and 3 columns for Matrix B**

SHIFT × ({) 2 , 3 SHIFT ÷ (}) →
OPTN F2 (MAT) F6 (▷) F2 (Dim)
F6 (▷) F1 (Mat) ALPHA log (B) EXE



• Modifying Matrices Using Matrix Commands

You can also use matrix commands to assign values to and recall values from an existing matrix, to fill in all cells of an existing matrix with the same value, to combine two matrices into a single matrix, and to assign the contents of a matrix column to a list file.

• To assign values to and recall values from an existing matrix

[OPTN]-[MAT]-[Mat]

Use the following format with the Mat command to specify a cell for value assignment and recall.

Mat X $[m, n]$

X = matrix name (A through Z, or Ans)

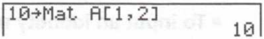
m = row number

n = column number

Example 1 **To assign 10 to the cell at row 1, column 2 of the following matrix:**

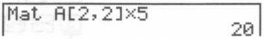
$$\text{Matrix A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix}$$

1 0 → OPTN F2 (MAT) F1 (Mat)
ALPHA X,θ,T (A) SHIFT + ([ ) 1 , 2
SHIFT − ( ]) EXE


```
10→Mat A[1,2]
                   10
```

Example 2 **Multiply the value in the cell at row 2, column 2 of the above matrix by 5**

OPTN F2 (MAT) F1 (Mat)
ALPHA X,θ,T (A) SHIFT + ([ ) 2 , 2
SHIFT − ( ]) × 5 EXE

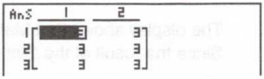

```
Mat A[2,2]×5
                   20
```

• To fill a matrix with identical values and to combine two matrices into a single matrix [OPTN]-[MAT]-[Fill]/[Aug]

Use the Fill command to fill all the cells of an existing matrix with an identical value and the Augment command to combine two existing matrices into a single matrix.

Example 1 **To fill all of the cells of Matrix A with the value 3**

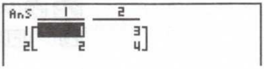
OPTN F2 (MAT) F6 (▷) F3 (Fill)
3 , F6 (▷) F1 (Mat) ALPHA X,θ,T (A) EXE
F1 (Mat) ALPHA X,θ,T (A) EXE


```
Ans    1       2
 1[    3       3]
 2     3       3
 3     3       3]
```

Example 2 **To combine the following two matrices:**

$$A = \begin{bmatrix} 1 \\ 2 \end{bmatrix} \quad B = \begin{bmatrix} 3 \\ 4 \end{bmatrix}$$

OPTN F2 (MAT) F5 (Aug)
F1 (Mat) ALPHA X,θ,T (A) ,
F1 (Mat) ALPHA log (B) EXE


```
Ans    1       2
 1[    1       3]
 2     2       4]
```

- The two matrices you combine must have the same number of rows. An error occurs if you try to combine two matrices that have different number of rows.
- You can use Matrix Answer Memory to assign the results of the above matrix input and edit operations to a matrix variable. To do so, use the following syntax.

Fill (n, Mat α)
Augment (Mat α, Mat β) → Mat γ

In the above, α, β, and γ are any variable names A through Z, and n is any value.

The above does not affect the contents of Matrix Answer Memory.

• To assign the contents of a matrix column to a list [OPTN]-[MAT]-[M→L]

Use the following format with the Mat→List command to specify a column and a list.

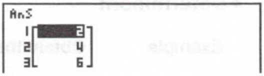
Mat → List (Mat X, m) → List n

X = matrix name (A through Z)
m = column number
n = list number

Example **To assign the contents of column 2 of the following matrix to list 1:**

$$\textbf{Matrix A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix}$$

OPTN F2 (MAT) F2 (M→L)
F1 (Mat) ALPHA X,θ,T (A) , 2)
→ OPTN F1 (LIST) F1 (List) 1 EXE
F1 (List) 1 EXE



```
AnS
 1[   2]
 2[   4]
 3[   6]
```

Matrix Calculations

[OPTN]-[MAT]

Use the matrix command menu to perform matrix calculation operations.

• To display the matrix commands

1. From the Main Menu, enter the **RUN • MAT** mode.
2. Press OPTN to display the option menu.
3. Press F2 (MAT) to display the matrix command menu.

The following describes only the matrix commands that are used for matrix arithmetic operations.

- {**Mat**} ... {Mat command (matrix specification)}
- {**Det**} ... {Det command (determinant command)}
- {**Trn**} ... {Trn command (transpose matrix command)}
- {**Iden**} ... {Identity command (identity matrix input)}
- {**Ref**} ... {Ref command (row echelon form command)}
- {**Rref**} ... {Rref command (reduced row echelon form command)}

All of the following examples assume that matrix data is already stored in memory.

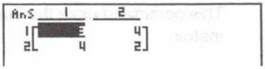
• Matrix Arithmetic Operations

[OPTN]-[MAT]-[Mat]/[Iden]

Example 1 **To add the following two matrices (Matrix A + Matrix B):**

$$A = \begin{bmatrix} 1 & 1 \\ 2 & 1 \end{bmatrix} \qquad B = \begin{bmatrix} 2 & 3 \\ 2 & 1 \end{bmatrix}$$

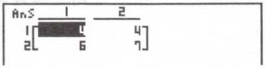
AC OPTN F2 (MAT) F1 (Mat) ALPHA X,θ,T (A) +
F1 (Mat) ALPHA log (B) EXE



```
AnS   1      2
 1[   3      4]
 2[   4      2]
```

Example 2 **To multiply the two matrices in Example 1 (Matrix A × Matrix B)**

AC OPTN F2 (MAT) F1 (Mat) ALPHA X,θ,T (A) ×
F1 (Mat) ALPHA log (B) EXE



```
AnS   1      2
 1[   4      4]
 2[   6      7]
```

- The two matrices must have the same dimensions in order to be added or subtracted. An error occurs if you try to add or subtract matrices of different dimensions.
- For multiplication (Matrix 1 × Matrix 2), the number of columns in Matrix 1 must match the number of rows in Matrix 2. Otherwise, an error occurs.

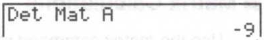
• Determinant

[OPTN]-[MAT]-[Det]

Example **Obtain the determinant for the following matrix:**

$$\textbf{Matrix A} = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ -1 & -2 & 0 \end{bmatrix}$$

[OPTN] [F2](MAT) [F3](Det) [F1](Mat)
[ALPHA] [X,θ,T](A) [EXE]



```
Det Mat A
              -9
```

- Determinants can be obtained only for square matrices (same number of rows and columns). Trying to obtain a determinant for a matrix that is not square produces an error.
- The determinant of a 2 × 2 matrix is calculated as shown below.

$$|A| = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} = a_{11}a_{22} - a_{12}a_{21}$$

- The determinant of a 3 × 3 matrix is calculated as shown below.

$$|A| = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} = a_{11}a_{22}a_{33} + a_{12}a_{23}a_{31} + a_{13}a_{21}a_{32} - a_{11}a_{23}a_{32} - a_{12}a_{21}a_{33} - a_{13}a_{22}a_{31}$$

• Matrix Transposition

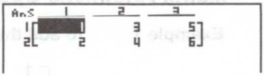
[OPTN]-[MAT]-[Trn]

A matrix is transposed when its rows become columns and its columns become rows.

Example **To transpose the following matrix:**

$$\textbf{Matrix A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix}$$

[OPTN] [F2](MAT) [F4](Trn) [F1](Mat)
[ALPHA] [X,θ,T](A) [EXE]



```
Ans    1        2        3
 1[    1        3        5]
 2[    2        4        6]
```

• Row Echelon Form

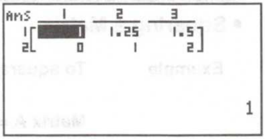
[OPTN]-[MAT]-[Ref]

This command uses the Gaussian elimination algorithm to find the row echelon form of a matrix.

Example **To find the row echelon form of the following matrix:**

$$\textbf{Matrix A} = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \end{bmatrix}$$

OPTN F2 (MAT) F6 (▷) F4 (Ref)
F6 (▷) F1 (Mat) ALPHA X,θ,T (A) EXE



```
Ans    1      2      3
 1[    1   1.25    1.5]
 2[    0      1      2]
                     1
```

• Reduced Row Echelon Form

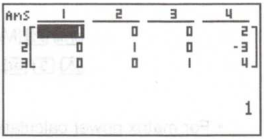
[OPTN]-[MAT]-[Rref]

This command finds the reduced row echelon form of a matrix.

Example **To find the reduced row echelon form of the following matrix:**

$$\textbf{Matrix A} = \begin{bmatrix} 2 & -1 & 3 & 19 \\ 1 & 1 & -5 & -21 \\ 0 & 4 & 3 & 0 \end{bmatrix}$$

OPTN F2 (MAT) F6 (▷) F5 (Rref)
F6 (▷) F1 (Mat) ALPHA X,θ,T (A) EXE



```
Ans    1      2      3      4
 1[    1      0      0      2]
 2[    0      1      0     -3]
 3[    0      0      1      4]
                            1
```

- The row echelon form and reduced row echelon form operation may not produce accurate results due to dropped digits.

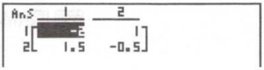
• Matrix Inversion

[x^{-1}]

Example **To invert the following matrix:**

$$\textbf{Matrix A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$$

OPTN F2 (MAT) F1 (Mat)
ALPHA X,θ,T (A) SHIFT) (x^{-1}) EXE



```
Ans    1      2
 1[   -2      1]
 2[  1.5   -0.5]
```

- Only square matrices (same number of rows and columns) can be inverted. Trying to invert a matrix that is not square produces an error.
- A matrix with a determinant of zero cannot be inverted. Trying to invert a matrix with determinant of zero produces an error.
- Calculation precision is affected for matrices whose determinant is near zero.
- A matrix being inverted must satisfy the conditions shown below.

$$\mathbf{A\,A^{-1} = A^{-1}\,A = E} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

The following shows the formula used to invert Matrix A into inverse matrix A^{-1}.

$$\mathbf{A} = \begin{bmatrix} a & b \\ c & d \end{bmatrix}$$

$$\mathbf{A^{-1}} = \frac{1}{ad - bc} \begin{bmatrix} d & -b \\ -c & a \end{bmatrix}$$

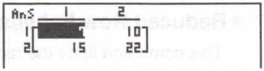
Note that ad – bc ≠ 0.

• Squaring a Matrix $[x^2]$

Example **To square the following matrix:**

$$\text{Matrix A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$$

OPTN F2 (MAT) F1 (Mat) ALPHA X,θ,T (A) x^2 EXE



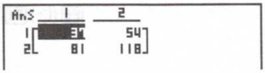
```
AnS    1         2
 1 [[illegible]      10 ]
 2 [     15      22 ]
```

• Raising a Matrix to a Power [^]

Example **To raise the following matrix to the third power:**

$$\text{Matrix A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$$

OPTN F2 (MAT) F1 (Mat) ALPHA X,θ,T (A)
∧ 3 EXE



```
AnS    1         2
 1 [     37      54 ]
 2 [     81     118 ]
```

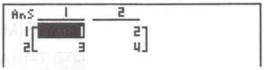
- For matrix power calculations, calculation is possible up to a power of 32766.

• Determining the Absolute Value, Integer Part, Fraction Part, and Maximum Integer of a Matrix [OPTN]-[NUM]-[Abs]/[Frac]/[Int]/[Intg]

Example **To determine the absolute value of the following matrix:**

$$\text{Matrix A} = \begin{bmatrix} 1 & -2 \\ -3 & 4 \end{bmatrix}$$

OPTN F6 (▷) F4 (NUM) F1 (Abs)
OPTN F2 (MAT) F1 (Mat) ALPHA X,θ,T (A) EXE



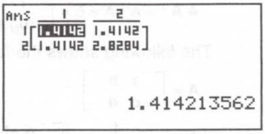
```
AnS    1         2
 1 [[illegible]       2 ]
 2 [      3       4 ]
```

• Complex Number Calculations with a Matrix

Example **To determine the absolute value of a matrix with the following complex number elements:**

$$\text{Matrix D} = \begin{bmatrix} -1+i & 1+i \\ 1+i & -2+2i \end{bmatrix}$$

AC OPTN F6 (▷) F4 (NUM) F1 (Abs)
OPTN F2 (MAT) F1 (Mat) ALPHA sin (D) EXE



```
AnS    1       2
 1 [1.4142  1.4142]
 2 [1.4142  2.8284]



                1.414213562
```

- The following complex number functions are supported in matrices.
  i, Abs, Arg, Conjg, ReP, ImP, ►a+bi, ►$r\angle\theta$

Matrix Calculation Precautions

- Determinants and inverse matrices are subject to error due to dropped digits.
- Matrix operations are performed individually on each cell, so calculations may require considerable time to complete.
- The calculation precision of displayed results for matrix calculations is ±1 at the least significant digit.
- If a matrix calculation result is too large to fit into Matrix Answer Memory, an error occurs.
- You can use the following operation to transfer Matrix Answer Memory contents to another matrix (or when Matrix Answer Memory contains a determinant to a variable).

  MatAns → Mat α

  In the above, α is any variable name A through Z. The above does not affect the contents of Matrix Answer Memory.

9. Metric Conversion Calculations

You can convert values from one unit of measurement to another. Measurement units are classified according to the following 11 categories. The indicators in the "Display Name" column show the text that appears in the calculator's function menu.

Display Name	Category	Display Name	Category	Display Name	Category
LENG	Length	TMPR	Temperature	PRES	Pressure
AREA	Area	VELO	Velocity	ENGY	Energy/Work
VLUM	Volume	MASS	Mass	PWR	Power
TIME	Time	FORC	Force/Weight		

You can convert from any unit in a category to any other unit in the same category.

- Attempting to convert from a unit in one category (such as "AREA") to a unit in another category (such as "TIME") results in a Conversion ERROR.
- See the "Unit Conversion Command List" (page 2-47) for information about the units included in each category.

■ Performing a Unit Conversion Calculation [OPTN]-[CONV]

Input the value you are converting from and the conversion commands using the syntax shown below to perform a unit conversion calculation.

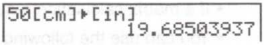
{value converting from}{conversion command 1} ► {conversion command 2}

- Use {conversion command 1} to specify the unit being converted from and {conversion command 2} to specify the unit being converted to.
- ► is a command that links the two conversion commands. This command is always available at F1(►) of the Conversion menu.

- Real numbers or a list that contains real number elements only can be used as the value being converted from. When values being converted from are input into a list (or when list memory is specified), conversion calculation is performed for each element in the list and calculation results are returned in list format (ListAns screen).
- A complex number cannot be used as a value to be converted from. An error occurs if even a single element of a list being used as the value being converted from contains a complex number.

Example 1 **To convert 50cm to inches**

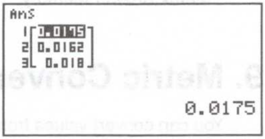
AC 5 0 OPTN F6(▷) F1(CONV) F2(LENG)
5(cm) F1(▶) F2(LENG) ▶ 2(in) EXE



```
50[cm]▸[in]
          19.68503937
```

Example 2 **To convert {175, 162, 180} square meters to hectares**

AC SHIFT ×({) 1 7 5 , 1 6 2 ,
1 8 0 SHIFT ÷(})
OPTN F6(▷) F1(CONV) F3(AREA) 2(m²)
F1(▶) F3(AREA) 3(ha) EXE



```
Ans
 1[0.0175]
 2[0.0162]
 3[0.018 ]

               0.0175
```

Unit Conversion Command List

Cat.	Display Name	Unit
Length	fm	fermi
	Å	angstrom
	µm	micrometer
	mm	millimeter
	cm	centimeter
	m	meter
	km	kilometer
	AU	astronomical unit
	l.y.	light year
	pc	parsec
	Mil	1/1000 inch
	in	inch
	ft	foot
	yd	yard
	fath	fathom
	rd	rod
	mile	mile
	n mile	nautical mile
Area	cm^2	square centimeter
	m^2	square meter
	ha	hectare
	km^2	square kilometer
	in^2	square inch
	ft^2	square foot
	yd^2	square yard
	acre	acre
	mile^2	square mile

Cat.	Display Name	Unit
Volume	cm^3	cubic centimeter
	mL	milliliter
	L	liter
	m^3	cubic meter
	in^3	cubic inch
	ft^3	cubic foot
	fl_oz(UK)	ounce
	fl_oz(US)	fluid ounce (U.S.)
	gal(US)	gallon
	gal(UK)	UK gallon
	pt	pint
	qt	quart
	tsp	teaspoon
	tbsp	tablespoon
	cup	cup
Time	ns	nanosecond
	µs	microsecond
	ms	millisecond
	s	second
	min	minute
	h	hour
	day	day
	week	week
	yr	year
	s-yr	sidereal year
	t-yr	tropical year

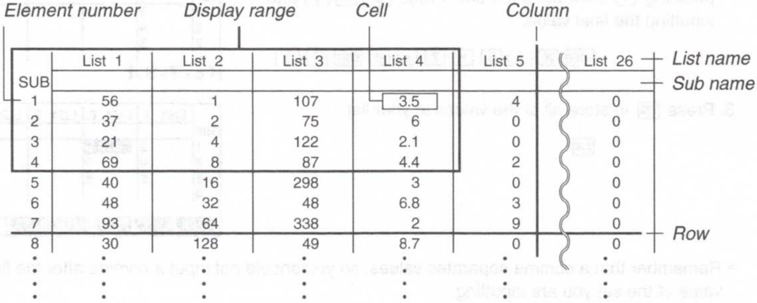
Cat.	Display Name	Unit
Temperature	°C	degrees Celsius
	K	Kelvin
	°F	degrees Fahrenheit
	°R	degrees Rankine
Velocity	m/s	meter per second
	km/h	kilometer per hour
	knot	knot
	ft/s	foot per second
	mile/h	mile per hour
Mass	u	atomic mass unit
	mg	milligram
	g	gram
	kg	kilogram
	mton	metric ton
	oz	avoirdupois ounce
	lb	pound mass
	slug	slug
	ton(short)	ton, short (2000lbm)
	ton(long)	ton, long (2240lbm)
Force/Weight	N	newton
	lbf	pound of force
	tonf	ton of force
	dyne	dyne
	kgf	kilogram of force

Cat.	Display Name	Unit
Pressure	Pa	Pascal
	kPa	Kilo Pascal
	$\mathrm{mmH_2O}$	millimeter of water
	mmHg	millimeter of Mercury
	atm	atmosphere
	$\mathrm{inH_2O}$	inch of water
	inHg	inch of Mercury
	$\mathrm{lbf/in^2}$	pound per square inch
	bar	bar
	$\mathrm{kgf/cm^2}$	kilogram force per square centimeter
Energy/Work	eV	electron Volt
	J	Joule
	$\mathrm{cal_{th}}$	$\mathrm{calorie_{th}}$
	$\mathrm{cal_{15}}$	calorie (15°C)
	$\mathrm{cal_{IT}}$	$\mathrm{calorie_{IT}}$
	$\mathrm{kcal_{th}}$	$\mathrm{kilocalorie_{th}}$
	$\mathrm{kcal_{15}}$	kilocalorie (15°C)
	$\mathrm{kcal_{IT}}$	$\mathrm{kilocalorie_{IT}}$
	l-atm	liter atmosphere
	kW•h	kilowatt hour
	ft•lbf	foot-pound
	Btu	British thermal unit
	erg	erg
	kgf•m	kilogram force meter
Power	W	watt
	$\mathrm{cal_{th}/s}$	calorie per second
	hp	horsepower
	ft•lbf/s	foot-pound per second
	Btu/min	British thermal unit per minute

Source: NIST Special Publication 811 (1995)

Chapter 3 List Function

A list is a storage place for multiple data items.
This calculator lets you store up to 26 lists in a single file, and you can store up to six files in memory. Stored lists can be used in arithmetic and statistical calculations, and for graphing.



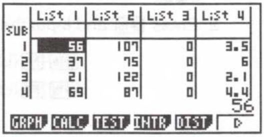
	List 1	List 2	List 3	List 4	List 5	List 26
SUB						
1	56	1	107	3.5	4	0
2	37	2	75	6	0	0
3	21	4	122	2.1	0	0
4	69	8	87	4.4	2	0
5	40	16	298	3	0	0
6	48	32	48	6.8	3	0
7	93	64	338	2	9	0
8	30	128	49	8.7	0	0
⋮	⋮	⋮	⋮	⋮	⋮	⋮

1. Inputting and Editing a List

When you enter the **STAT** mode, the "List Editor" will appear first. You can use the List Editor to input data into a list and to perform a variety of other list data operations.

• To input values one-by-one

Use the cursor keys to move the highlighting to the list name, sub name or cell you want to select. Note that ⏷ does not move the highlighting to a cell that does not contain a value.



	List 1	List 2	List 3	List 4
SUB				
1	56	107	0	3.5
2	37	75	0	6
3	21	122	0	2.1
4	69	87	0	4.4

56

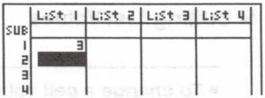
The screen automatically scrolls when the highlighting is located at either edge of the screen.

The following example is performed starting with the highlighting located at Cell 1 of List 1.

1. Input a value and press EXE to store it in the list.

   3 EXE

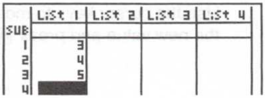
   - The highlighting automatically moves down to the next cell for input.



	List 1	List 2	List 3	List 4
SUB				
1	3			
2				
3				
4				

2. Input the value 4 in the second cell, and then input the result of 2 + 3 in the next cell.

   4 EXE 2 + 3 EXE

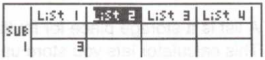


	List 1	List 2	List 3	List 4
SUB				
1	3			
2	4			
3	5			
4				

- You can also input the result of an expression or a complex number into a cell.
- You can input values up to 999 cells in a single list.

• To batch input a series of values

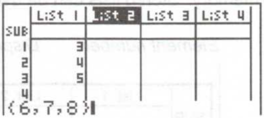
1. Use the cursor keys to move the highlighting to another list.



SUB	List 1	List 2	List 3	List 4
1	3			

2. Press SHIFT × ({), and then input the values you want, pressing , between each one. Press SHIFT ÷ (}) after inputting the final value.

   SHIFT × ({) 6 , 7 , 8 SHIFT ÷ (})

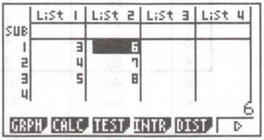


SUB	List 1	List 2	List 3	List 4
1	3			
2	4			
3	5			
4				

{6,7,8}

3. Press EXE to store all of the values in your list.

   EXE



SUB	List 1	List 2	List 3	List 4
1	3	6		
2	4	7		
3	5	8		
4				

6

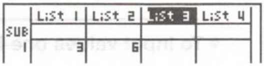
- Remember that a comma separates values, so you should not input a comma after the final value of the set you are inputting.

  Right: {34, 53, 78}

  Wrong: {34, 53, 78,}

You can also use list names inside of a mathematical expression to input values into another cell. The following example shows how to add the values in each row in List 1 and List 2, and input the result into List 3.

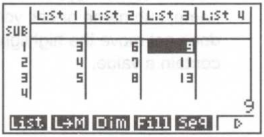
1. Use the cursor keys to move the highlighting to the name of the list where you want the calculation results to be input.



SUB	List 1	List 2	List 3	List 4
1	3	6		

2. Press OPTN and input the expression.

   OPTN F1 (LIST) F1 (List) 1 +
   OPTN F1 (LIST) F1 (List) 2 EXE



SUB	List 1	List 2	List 3	List 4
1	3	6	9	
2	4	7	11	
3	5	8	13	
4				

9

- You can also use SHIFT 1 (List) in place of OPTN F1 (LIST) F1 (List).

■ Editing List Values

• To change a cell value

Use the cursor keys to move the highlighting to the cell whose value you want to change. Input the new value and press EXE to replace the old data with the new one.

• To edit the contents of a cell

1. Use the cursor keys to move the highlighting to the cell whose contents you want to edit.
2. Press F6(▷)F2(EDIT).
3. Make any changes in the data you want.

• To delete a cell

1. Use the cursor keys to move the highlighting to the cell you want to delete.
2. Press F6(▷)F3(DEL) to delete the selected cell and cause everything below it to be shifted up.

- The cell delete operation does not affect cells in other lists. If the data in the list whose cell you delete is somehow related to the data in neighboring lists, deleting a cell can cause related values to become misaligned.

• To delete all cells in a list

Use the following procedure to delete all the data in a list.

1. Use the cursor key to move the highlighting to any cell of the list whose data you want to delete.
2. Pressing F6(▷)F4(DEL•A) causes a confirmation message to appear.
3. Press F1(Yes) to delete all the cells in the selected list or F6(No) to abort the delete operation without deleting anything.

• To insert a new cell

1. Use the cursor keys to move the highlighting to the location where you want to insert the new cell.
2. Press F6(▷)F5(INS) to insert a new cell, which contains a value of 0, causing everything below it to be shifted down.

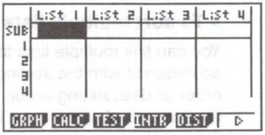
- The cell insert operation does not affect cells in other lists. If the data in the list where you insert a cell is somehow related to the data in neighboring lists, inserting a cell can cause related values to become misaligned.

■ Naming a List

You can assign List 1 through List 26 "sub names" of up to eight bytes each.

• To name a list

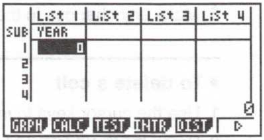
1. On the Setup screen, highlight "Sub Name" and then press F1(On)EXIT.
2. Use the cursor keys to move the highlighting to the SUB cell of the list you want to name.



3. Type in the name and then press [EXE].
   - To type in a name using alpha characters, press [SHIFT] [ALPHA] to enter the ALPHA-LOCK mode.

   Example: YEAR

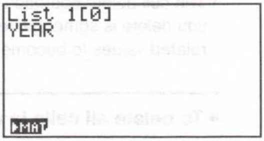
   [−] (Y) [cos] (E) [X,θ,T] (A) [6] (R) [EXE]



	List 1	List 2	List 3	List 4
SUB	YEAR			
1	0			
2				
3				
4				

- The following operation displays a sub name in the **RUN • MAT** mode.

  [SHIFT] [1] (List) *n* [SHIFT] [+] ([ ) [0] [SHIFT] [−] ( ]) [EXE]
  (*n* = list number from 1 to 26)



```
List 1[0]
YEAR
```

- Though you can input up to 8 bytes for the sub name, only the characters that can fit within the List Editor cell will be displayed.
- The List Editor SUB cell is not displayed when “Off” is selected for “Sub Name” on the Setup screen.

■ Sorting List Values

You can sort lists into either ascending or descending order. The highlighting can be located in any cell of the list.

• To sort a single list

Ascending order

1. While the lists are on the screen, press [F6] (▷) [F1] (TOOL) [F1] (SRT • A).
2. The prompt “How Many Lists?:” appears to ask how many lists you want to sort. Here we will input 1 to indicate we want to sort only one list.

   [1] [EXE]

3. In response to the “Select List List No:” prompt, input the number of the list you want to sort.

   [1] [EXE]

Descending order

Use the same procedure as that for the ascending order sort. The only difference is that you should press [F2] (SRT • D) in place of [F1] (SRT • A).

• To sort multiple lists

You can link multiple lists together for a sort so that all of their cells are rearranged in accordance with the sorting of a base list. The base list is sorted into either ascending order or descending order, while the cells of the linked lists are arranged so that the relative relationship of all the rows is maintained.

Ascending order

1. While the lists are on the screen, press F6(▷)F1(TOOL)F1(SRT • A).
2. The prompt "How Many Lists?:" appears to ask how many lists you want to sort. Here we will sort one base list linked to one other list, so we should input 2.

   2 EXE

3. In response to the "Select Base List List No:" prompt, input the number of the list you want to sort into ascending order. Here we will specify List 1.

   1 EXE

4. In response to the "Select Second List List No:" prompt, input the number of the list you want to link to the base list. Here we will specify List 2.

   2 EXE

Descending order

Use the same procedure as that for the ascending order sort. The only difference is that you should press F2(SRT•D) in place of F1(SRT•A).

- You can specify a value from 1 to 6 as the number of lists for sorting.
- If you specify a list more than once for a single sort operation, an error occurs.

  An error also occurs if lists specified for sorting do not have the same number of values (rows).

2. Manipulating List Data

List data can be used in arithmetic and function calculations. In addition, various list data manipulation functions make manipulation of list data quick and easy.

You can use list data manipulation functions in the **RUN • MAT**, **STAT**, **TABLE**, **EQUA** and **PRGM** modes.

■ Accessing the List Data Manipulation Function Menu

All of the following examples are performed after entering the **RUN • MAT** mode.

Press OPTN and then F1(LIST) to display the list data manipulation menu, which contains the following items.

- **{List}**/**{L→M}**/**{Dim}**/**{Fill}**/**{Seq}**/**{Min}**/**{Max}**/**{Mean}**/**{Med}**/**{Aug}**/**{Sum}**/**{Prod}**/**{Cuml}**/**{%}**/**{⊿}**

Note that all closing parentheses at the end of the following operations can be omitted.

• To transfer list contents to Matrix Answer Memory [OPTN]-[LIST]-[L→M]

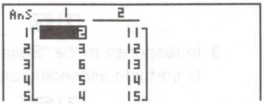
OPTN F1(LIST) F2(L→M) F1(List) <list number 1-26> , F1(List) <list number 1-26> ... , F1(List) <list number 1-26>) EXE

- You can skip input F1(List) in the part of the above operation.
- All the lists must contain the same number of data items. If they don't, an error occurs.

  Example: List → Mat (1, 2) EXE

Example **To transfer the contents of List 1 (2, 3, 6, 5, 4) to column 1, and the contents of List 2 (11, 12, 13, 14, 15) to column 2 of Matrix Answer Memory**

AC OPTN F1(LIST) F2(L→M)
F1(List) 1 , F1(List) 2) EXE



```
Ans   1    2
 1    2   11
 2    3   12
 3    6   13
 4    5   14
 5    4   15
```

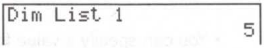
• To count the number of data items in a list [OPTN]-[LIST]-[Dim]

OPTN F1(LIST) F3(Dim) F1(List) <list number 1 - 26> EXE

- The number of cells a list contains is its "dimension."

Example **To count the number of values in List 1 (36, 16, 58, 46, 56)**

AC OPTN F1(LIST) F3(Dim)
F1(List) 1 EXE



```
Dim List 1
                  5
```

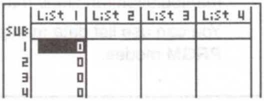
• To create a list by specifying the number of data items [OPTN]-[LIST]-[Dim]

Use the following procedure to specify the number of data in the assignment statement and create a list.

<number of data *n*> → OPTN F1(LIST) F3(Dim) F1(List) <list number 1 - 26> EXE (*n* = 1 - 999)

Example **To create five data items (each of which contains 0) in List 1**

AC 5 → OPTN F1(LIST) F3(Dim)
F1(List) 1 EXE



```
     List 1  List 2  List 3  List 4
SUB
 1       0
 2       0
 3       0
 4       0
```

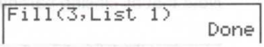
You can view the newly created list by entering the **STAT** mode.

• To replace all data items with the same value [OPTN]-[LIST]-[Fill]

OPTN F1(LIST) F4(Fill) <value> , F1(List) <list number 1 - 26>) EXE

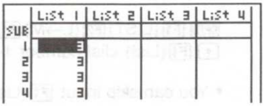
Example **To replace all data items in List 1 with the number 3**

AC OPTN F1(LIST) F4(Fill)
3 , F1(List) 1) EXE



```
Fill(3,List 1)
               Done
```

The following shows the new contents of List 1.



```
     List 1  List 2  List 3  List 4
SUB
 1       3
 2       3
 3       3
 4       3
```

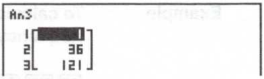
• To generate a sequence of numbers [OPTN]-[LIST]-[Seq]

OPTN F1(LIST) F5(Seq) <expression> , <variable name> , <start value> , <end value> , <increment>) EXE

- The result of this operation is stored in ListAns Memory.

Example **To input the number sequence $1^2, 6^2, 11^2$, into a list, using the function $f(x) = X^2$. Use a starting value of 1, an ending value of 11, and an increment of 5.**

AC OPTN F1(LIST) F5(Seq) X,θ,T x^2 ,
X,θ,T , 1 , 1 1 , 5) EXE



```
Ans
1[ 1]
2  36
3L 121]
```

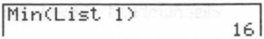
Specifying an ending value of 12, 13, 14, or 15 produces the same result as shown above since they are less than the value produced by the next increment (16).

• To find the minimum value in a list [OPTN]-[LIST]-[Min]

OPTN F1(LIST) F6(▷) F1(Min) F6(▷) F6(▷) F1(List) <list number 1 - 26>) EXE

Example **To find the minimum value in List 1 (36, 16, 58, 46, 56)**

AC OPTN F1(LIST) F6(▷) F1(Min)
F6(▷) F6(▷) F1(List) 1) EXE



```
Min(List 1)
             16
```

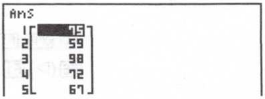
• To find which of two lists contains the greatest value [OPTN]-[LIST]-[Max]

OPTN F1(LIST) F6(▷) F2(Max) F6(▷) F6(▷) F1(List) <list number 1 - 26> , F1(List) <list number 1 - 26>) EXE

- The two lists must contain the same number of data items. If they don't, an error occurs.
- The result of this operation is stored in ListAns Memory.

Example **To find whether List 1 (75, 16, 98, 46, 56) or List 2 (35, 59, 58, 72, 67) contains the greatest value**

OPTN F1(LIST) F6(▷) F2(Max)
F6(▷) F6(▷) F1(List) 1 ,
F1(List) 2) EXE



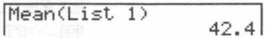
```
Ans
1[ 75]
2  59
3  98
4  72
5L 67]
```

• To calculate the mean of data items [OPTN]-[LIST]-[Mean]

OPTN F1(LIST) F6(▷) F3(Mean) F6(▷) F6(▷) F1(List) <list number 1 - 26>) EXE

Example **To calculate the mean of data items in List 1 (36, 16, 58, 46, 56)**

AC OPTN F1(LIST) F6(▷) F3(Mean)
F6(▷) F6(▷) F1(List) 1) EXE



```
Mean(List 1)
           42.4
```

• To calculate the median of data items of specified frequency

[OPTN]-[LIST]-[Med]

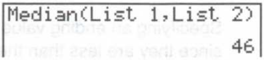
This procedure uses two lists: one that contains values and one that indicates the frequency (number of occurrences) of each value. The frequency of the data in Cell 1 of the first list is indicated by the value in Cell 1 of the second list, etc.

- The two lists must contain the same number of data items. If they don't, an error occurs.

OPTN F1(LIST) F6(▷) F4(Med) F6(▷) F6(▷) F1(List) <list number 1 - 26 (data)> , F1(List) <list number 1 - 26 (frequency)>) EXE

Example **To calculate the median of values in List 1 (36, 16, 58, 46, 56), whose frequency is indicated by List 2 (75, 89, 98, 72, 67)**

AC OPTN F1(LIST) F6(▷) F4(Med)
F6(▷) F6(▷) F1(List) 1 ,
F1(List) 2) EXE



```
Median(List 1,List 2)
                     46
```

• To combine lists

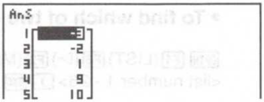
[OPTN]-[LIST]-[Aug]

- You can combine two different lists into a single list. The result of a list combination operation is stored in ListAns memory.

OPTN F1(LIST) F6(▷) F5(Aug) F6(▷) F6(▷) F1(List) <list number 1 - 26> , F1(List) <list number 1 - 26>) EXE

Example **To combine the List 1 (–3, –2) and List 2 (1, 9, 10)**

AC OPTN F1(LIST) F6(▷) F5(Aug)
F6(▷) F6(▷) F1(List) 1 ,
F1(List) 2) EXE



```
Ans
1[ -3]
2  -2
3   1
4   9
5[ 10]
```

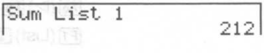
• To calculate the sum of data items in a list

[OPTN]-[LIST]-[Sum]

OPTN F1(LIST) F6(▷) F6(▷) F1(Sum) F6(▷) F1(List) <list number 1 - 26> EXE

Example **To calculate the sum of data items in List 1 (36, 16, 58, 46, 56)**

AC OPTN F1(LIST) F6(▷) F6(▷) F1(Sum)
F6(▷) F1(List) 1 EXE



```
Sum List 1
                212
```

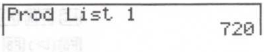
• To calculate the product of values in a list

[OPTN]-[LIST]-[Prod]

OPTN F1(LIST) F6(▷) F6(▷) F2(Prod) F6(▷) F1(List) <list number 1 - 26> EXE

Example **To calculate the product of values in List 1 (2, 3, 6, 5, 4)**

AC OPTN F1(LIST) F6(▷) F6(▷) F2(Prod)
F6(▷) F1(List) 1 EXE



```
Prod List 1
                720
```

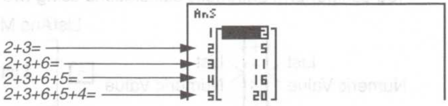
• To calculate the cumulative frequency of each data item [OPTN]-[LIST]-[Cuml]

OPTN F1 (LIST) F6 (▷) F6 (▷) F3 (Cuml) F6 (▷) F1 (List) <list number 1 - 26> EXE

- The result of this operation is stored in ListAns Memory.

Example **To calculate the cumulative frequency of each data item in List 1 (2, 3, 6, 5, 4)**

AC OPTN F1 (LIST) F6 (▷) F6 (▷) F3 (Cuml)
F6 (▷) F1 (List) 1 EXE



2+3=
2+3+6=
2+3+6+5=
2+3+6+5+4=
Ans
1 2
2 5
3 11
4 16
5 20

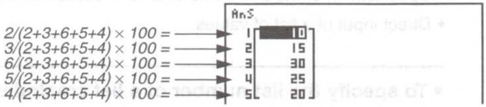
• To calculate the percentage represented by each data item [OPTN]-[LIST]-[%]

OPTN F1 (LIST) F6 (▷) F6 (▷) F4 (%) F6 (▷) F1 (List) <list number 1 - 26> EXE

- The above operation calculates what percentage of the list total is represented by each data item.
- The result of this operation is stored in ListAns Memory.

Example **To calculate the percentage represented by each data item in List 1 (2, 3, 6, 5, 4)**

AC OPTN F1 (LIST) F6 (▷) F6 (▷) F4 (%)
F6 (▷) F1 (List) 1 EXE



2/(2+3+6+5+4) × 100 =
3/(2+3+6+5+4) × 100 =
6/(2+3+6+5+4) × 100 =
5/(2+3+6+5+4) × 100 =
4/(2+3+6+5+4) × 100 =
Ans
1 10
2 15
3 30
4 25
5 20

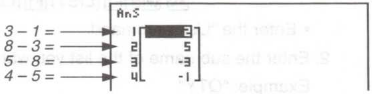
• To calculate the differences between neighboring data inside a list [OPTN]-[LIST]-[⊿]

OPTN F1 (LIST) F6 (▷) F6 (▷) F5 (⊿) <list number 1 - 26> EXE

- The result of this operation is stored in ListAns Memory.

Example **To calculate the difference between the data items in List 1 (1, 3, 8, 5, 4)**

AC OPTN F1 (LIST) F6 (▷) F6 (▷) F5 (⊿)
1 EXE

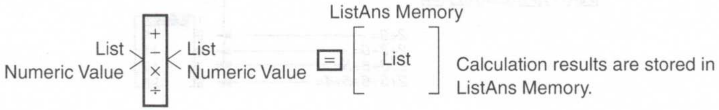


3 − 1 =
8 − 3 =
5 − 8 =
4 − 5 =
Ans
1 2
2 5
3 -3
4 -1

- You can specify the storage location in list memory for a calculation result produced by a list calculation whose result is stored in ListAns memory. For example, specifying "⊿List 1 → List 2" will store the result of ⊿List 1 in List 2.
- The number of cells in the new ⊿List is one less than the number of cells in the original list.
- An error occurs if you execute ⊿List for a list that has no data or only one data item.

3. Arithmetic Calculations Using Lists

You can perform arithmetic calculations using two lists or one list and a numeric value.



■ Error Messages

- A calculation involving two lists performs the operation between corresponding cells. Because of this, an error occurs if the two lists do not have the same number of values (which means they have different "dimensions").
- An error occurs whenever an operation involving any two cells generates a mathematical error.

■ Inputting a List into a Calculation

There are three methods you can use to input a list into a calculation.

- Specification of the list number of a list created with List Editor.
- Specification of the sub name of a list created with List Editor.
- Direct input of a list of values.

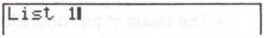
• To specify the list number of a list created with List Editor

1. In the **RUN • MAT** mode, perform the following key operation.

   AC OPTN F1(LIST) F1(List)

   - Enter the "List" command.

2. Enter the list number (integer from 1 to 26) you want to specify.



```
List 1
```

• To specify the sub name of a list created with List Editor

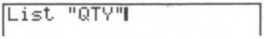
1. In the **RUN • MAT** mode, perform the following key operation.

   AC OPTN F1(LIST) F1(List)

   - Enter the "List" command.

2. Enter the sub name of the list you want to specify, enclosed in double quotes (" ").

   Example: "QTY"



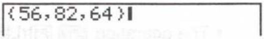
```
List "QTY"
```

• To directly input a list of values

You can also directly input a list of values using {, }, and ,.

Example **To input the list: 56, 82, 64**

SHIFT × ({) 5 6 , 8 2 ,
6 4 SHIFT ÷ (})



{56,82,64}

• To assign the contents of one list to another list

Use → to assign the contents of one list to another list.

Example **To assign the contents of List 3 (41, 65, 22) to List 1**

OPTN F1 (LIST) F1 (List) 3 → F1 (List) 1 EXE

In place of F1 (LIST) F1 (List) 3 operation in the above procedure, you could input SHIFT × ({) 4 1 , 6 5 , 2 2 SHIFT ÷ (}).

• To recall the value in a specific list cell

You can recall the value in a specific list cell and use it in a calculation. Specify the cell number by enclosing it inside square brackets.

Example **To calculate the sine of the value stored in Cell 3 of List 2**

sin OPTN F1 (LIST) F1 (List) 2 SHIFT + ([ ) 3 SHIFT − ( ]) EXE

• To input a value into a specific list cell

You can input a value into a specific list cell inside a list. When you do, the value that was previously stored in the cell is replaced with the new value you input.

Example **To input the value 25 into Cell 2 of List 3**

2 5 → OPTN F1 (LIST) F1 (List) 3 SHIFT + ([ ) 2 SHIFT − ( ]) EXE

■ Recalling List Contents

Example **To recall the contents of List 1**

OPTN F1 (LIST) F1 (List) 1 EXE

- The above operation displays the contents of the list you specify and also stores them in ListAns Memory. You can then use the ListAns Memory contents in a calculation.

• To use list contents in ListAns Memory in a calculation

Example **To multiply the list contents in ListAns Memory by 36**

OPTN F1(LIST) F1(List) SHIFT (−)(Ans) × 3 6 EXE

- The operation OPTN F1(LIST) F1(List) SHIFT (−)(Ans) recalls ListAns Memory contents.
- This operation replaces current ListAns Memory contents with the result of the above calculation.

■ Graphing a Function Using a List

When using the graphing functions of this calculator, you can input a function such as Y1 = List 1X. If List 1 contains the values 1, 2, 3, this function will produces three graphs: Y = X, Y = 2X, Y = 3X.

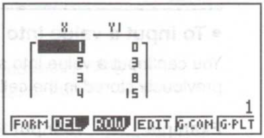
There are certain limitations on using lists with graphing functions.

■ Inputting Scientific Calculations into a List

You can use the numeric table generation functions in the **TABLE** mode to input values that result from certain scientific function calculations into a list. To do this, first generate a table and then use the list copy function to copy the values from the table to the list.

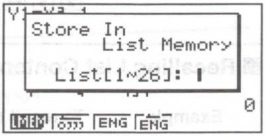
Example **To use the TABLE mode to create a number table for the formula (Y1 = x^2 −1), and then copy the table to List 1 in the STAT mode**

1. In the **TABLE** mode, input the formula Y1 = x^2 −1.
2. Create the number table.



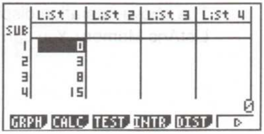
X	Y1
1	0
2	3
3	8
4	15

3. Use ▶ to move the highlighting to the Y1 column.
4. Press OPTN F1(LMEM).



Store In
List Memory
List[1~26]:

5. Press 1 EXE.
6. Enter the **STAT** mode to confirm that **TABLE** mode column Y1 has been copied to List 1.



	List 1	List 2	List 3	List 4
SUB				
1	0			
2	3			
3	8			
4	15			

■ Performing Scientific Function Calculations Using a List

Lists can be used just as numeric values are in scientific function calculations. When the calculation produces a list as a result, the list is stored in ListAns Memory.

Example **To use List 3** $\begin{bmatrix} 41 \\ 65 \\ 22 \end{bmatrix}$ **to perform sin (List 3)**

Use radians as the angle unit.

sin OPTN F1(LIST) F1(List) 3 EXE

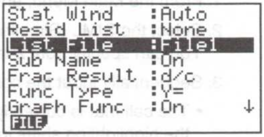
4. Switching Between List Files

You can store up to 26 lists (List 1 to List 26) in each file (File 1 to File 6). A simple operation lets you switch between list files.

• To switch between list files

1. From the Main Menu, enter the **STAT** mode.

   Press SHIFT MENU (SET UP) to display the **STAT** mode Setup screen.

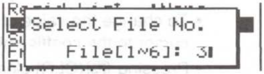


```
Stat Wind   :Auto
Resid List  :None
List File   :File1
Sub Name    :On
Frac Result :d/c
Func Type   :Y=
Graph Func  :On      ↓
FILE
```

2. Use ⊙ to highlight "List File".
3. Press F1(FILE) and then input the number of the list file you want to use.

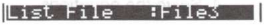
Example **To select File 3**

F1(FILE) 3



```
Select File No.
    File[1~6]: 3
```

EXE

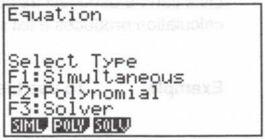


```
List File   :File3
```

All subsequent list operations are applied to the lists contained in the file you select (List File 3 in the above example).

Chapter 4 Equation Calculations

From the Main Menu, enter the **EQUA** mode.


Equation

Select Type
F1:Simultaneous
F2:Polynomial
F3:Solver

- {**SIML**} ... {linear equation with 2 to 6 unknowns}
- {**POLY**} ... {degree 2 to 6 equation}
- {**SOLV**} ... {solve calculation}

1. Simultaneous Linear Equations

You can solve simultaneous linear equations with two to six unknowns.

- Simultaneous Linear Equation with Two Unknowns:

  $a_1x + b_1y = c_1$

  $a_2x + b_2y = c_2$

- Simultaneous Linear Equation with Three Unknowns:

  $a_1x + b_1y + c_1z = d_1$

  $a_2x + b_2y + c_2z = d_2$

  $a_3x + b_3y + c_3z = d_3$

  $\vdots$

1. From the Main Menu, enter the **EQUA** mode.
2. Select the SIML (Simultaneous) mode, and specify the number of unknowns (variables). You can specify from 2 to 6 unknowns.
3. Sequentially input the coefficients.
   - The cell that is currently selected for input is highlighted. Each time you input a coefficient, the highlighting shifts in the sequence:

     $a_1 \rightarrow b_1 \rightarrow c_1 \rightarrow \ldots\ a_n \rightarrow b_n \rightarrow c_n \rightarrow (n = 2 \text{ to } 6)$
   - You can also input fractions and values assigned to variables as coefficients.
   - You can cancel the value you are inputting for the current coefficient by pressing EXIT at any time before you press EXE to store the coefficient value. This returns to the coefficient to what it was before you input anything. You can then input another value if you want.
   - To change the value of a coefficient that you already stored by pressing EXE, move the cursor to the coefficient you want to edit. Next, input the value you want to change to.
   - Pressing F3(CLR) clears all coefficients to zero.
4. Solve the equations.

Example **To solve the following simultaneous linear equations for x, y, and z**

$$\begin{aligned} 4x + y - 2z &= -1 \\ x + 6y + 3z &= 1 \\ -5x + 4y + z &= -7 \end{aligned}$$

① MENU EQUA

② F1 (SIML)

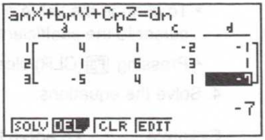
F2 (3)

③ 4 EXE 1 EXE (−) 2 EXE (−) 1 EXE

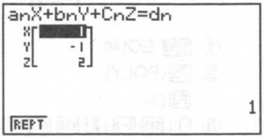
1 EXE 6 EXE 3 EXE 1 EXE

(−) 5 EXE 4 EXE 1 EXE (−) 7 EXE

④ F1 (SOLV)



```
anX+bnY+CnZ=dn
        a       b       c       d
  1[    4       1      -2      -1]
  2[    1       6       3       1]
  3[   -5       4       1      -7]
                               -7
SOLV DEL  CLR EDIT
```



```
anX+bnY+CnZ=dn
  X[    1]
  Y[   -1]
  Z[    2]

                                1
REPT
```

- Internal calculations are performed using a 15-digit mantissa, but results are displayed using a 10-digit mantissa and a 2-digit exponent.
- Simultaneous linear equations are solved by inverting the matrix containing the coefficients of the equations. For example, the following shows the solution (x, y, z) of a simultaneous linear equation with three unknowns.

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{bmatrix}^{-1} \begin{bmatrix} d_1 \\ d_2 \\ d_3 \end{bmatrix}$$

  Because of this, precision is reduced as the value of the determinant approaches zero. Also, simultaneous equations with three or more unknowns may take a very long time to solve.
- An error occurs if the calculator is unable to find a solution.
- After calculation is complete, you can press F1 (REPT), change coefficient values, and then re-calculate.

2. High-order Equations from 2nd to 6th Degree

Your calculator can be used to solve high-order equations from 2nd to 6th degree.

- Quadratic Equation: $ax^2 + bx + c = 0$ ($a \neq 0$)
- Cubic Equation: $ax^3 + bx^2 + cx + d = 0$ ($a \neq 0$)
- Quartic Equation: $ax^4 + bx^3 + cx^2 + dx + e = 0$ ($a \neq 0$)

⋮

1. From the Main Menu, enter the **EQUA** mode.
2. Select the POLY (Polynomial) mode, and specify the degree of the equation.

   You can specify a degree 2 to 6.
3. Sequentially input the coefficients.
   - The cell that is currently selected for input is highlighted. Each time you input a coefficient, the highlighting shifts in the sequence:

     $a \rightarrow b \rightarrow c \rightarrow \ldots$
   - You can also input fractions and values assigned to variables as coefficients.
   - You can cancel the value you are inputting for the current coefficient by pressing EXIT at any time before you press EXE to store the coefficient value. This returns to the coefficient to what it was before you input anything. You can then input another value if you want.

- To change the value of a coefficient that you already stored by pressing EXE, move the cursor to the coefficient you want to edit. Next, input the value you want to change to.
- Pressing F3(CLR) clears all coefficients to zero.

4. Solve the equations.

Example **To solve the cubic equation (Angle unit = Rad)**

$$x^3 - 2x^2 - x + 2 = 0$$

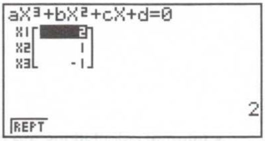
① MENU EQUA

② F2(POLY)

F2(3)

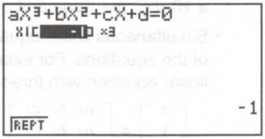
③ 1 EXE (-) 2 EXE (-) 1 EXE 2 EXE

④ F1(SOLV)



```
aX³+bX²+cX+d=0
 X1[     2]
 X2      1
 X3     -1]
                 2
REPT
```

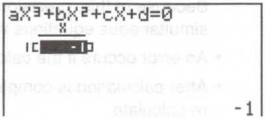
Multiple Solutions (Example: $x^3 + 3x^2 + 3x + 1 = 0$)



```
aX³+bX²+cX+d=0
 X1[    -1] ×3

                -1
REPT
```

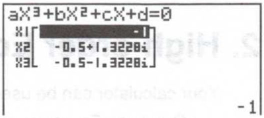
Complex Number Solution (Example: $x^3 + 2x^2 + 3x + 2 = 0$)

Complex Mode: Real (page 1-15)



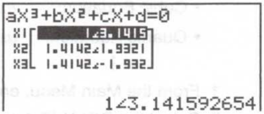
```
aX³+bX²+cX+d=0
      X
  1[    -1]

                -1
```

Complex Mode: $a+bi$



```
aX³+bX²+cX+d=0
 X1[             -1]
 X2  -0.5+1.3228i
 X3  -0.5-1.3228i]

                -1
```

Complex Mode: $r\angle\theta$



```
aX³+bX²+cX+d=0
 X1[        1∠3.1415]
 X2  1.4142∠1.9321
 X3  1.4142∠-1.932]

      1∠3.141592654
```

- Internal calculations are performed using a 15-digit mantissa, but results are displayed using a 10-digit mantissa and a 2-digit exponent.
- It may take considerable time for the calculation result of a high-order equation of 3rd degree or higher to appear on the display.
- An error occurs if the calculator is unable to find a solution.
- High-order equation calculations may not produce accurate results when the equation has multiple solutions.
- After calculation is complete, you can press F1(REPT), change coefficient values, and then re-calculate.

3. Solve Calculations

The Solve Calculation mode lets you determine the value of any variable in a formula without having to solve the equation.

1. From the Main Menu, enter the **EQUA** mode.
2. Select the SOLV (Solver) mode, and input the equation as it is written.
   - If you do not input an equals sign, the calculator assumes that the expression is to the left of the equals sign, and there is a zero to the right.
   - An error occurs if you input more than one equals sign.
3. In the table of variables that appears on the display, input values for each variable.
   - You can also specify values for Upper and Lower to define the upper and lower limits of the range of solutions.
   - An error occurs if the solution falls outside the range you specify.
4. Select the variable for which you want to solve to obtain the solution.
   "Lft" and "Rgt" indicate the left and right sides that are calculated using the solution.[*1]

[*1] Solutions are approximated using Newton's method. Lft and Rgt values are displayed for confirmation, because Newton's method may produce results that are the real solution. The closer the difference between the Lft and Rgt values is to zero, the lower degree of error in the result.

Example **An object thrown into the air at initial velocity V takes time T to reach height H. Use the following formula to solve for initial velocity V when H = 14 (meters), T = 2 (seconds) and gravitational acceleration is G = 9.8 (m/s^2).**

$H = VT - 1/2\ GT^2$

① MENU EQUA

② F3(SOLV)

ALPHA F↔D(H) SHIFT ·(=) ALPHA 2(V) ALPHA ÷(T) −
(1 ÷ 2) ALPHA a b/c(G) ALPHA ÷(T) x^2 EXE

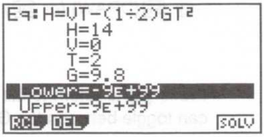
③ 1 4 EXE(H = 14)

0 EXE(V = 0)

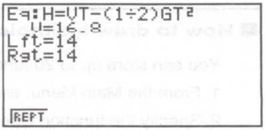
2 EXE(T = 2)

9 · 8 EXE(G = 9.8)

④ Press ▲ ▲ ▲ to highlight V = 0, and then press F6(SOLV).



```
Eq:H=VT-(1÷2)GT²
      H=14
      V=0
      T=2
      G=9.8
 Lower=-9E+99
 Upper=9E+99
```



```
Eq:H=VT-(1÷2)GT²
   V=16.8
Lft=14
Rgt=14
```

- The message "Retry" appears on the display when the calculator judges that convergence is not sufficient for the displayed results.
- A Solve operation will produce a single solution. Use POLY when you want to obtain multiple solutions for a high-order equation (such as $ax^2 + bx + c = 0$).

Chapter 5 Graphing

Select the icon in the Main Menu that suits the type of graph you want to draw or the type of table you want to generate.

- **GRAPH** … General function graphing
- **RUN•MAT** … Manual graphing (pages 5-12 to 5-15)
- **TABLE** … Number table generation (pages 5-15 to 5-19)
- **DYNA** … Dynamic graphing (pages 5-19 to 5-22)
- **RECUR** … Recursion graphing or number table generation (pages 5-22 to 5-26)
- **CONICS** … Conic section graphing (pages 5-26 to 5-27)

1. Sample Graphs

■ How to draw a simple graph (1)

To draw a graph, simply input the applicable function.

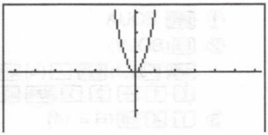
1. From the Main Menu, enter the **GRAPH** mode.
2. Input the function you want to graph.
   Here you would use the V-Window to specify the range and other parameters of the graph. See page 5-2.
3. Draw the graph.

Example **To graph $y = 3x^2$**

① MENU GRAPH

② 3 X,θ,T x^2 EXE

③ F6(DRAW) (or EXE)



- Press AC to return to the screen in step 2 (Graph relation list). After drawing a graph, you can toggle between the Graph relation list and graph screen by pressing SHIFT F6(G↔T).

■ How to draw a simple graph (2)

You can store up to 20 functions in memory and then select the one you want for graphing.

1. From the Main Menu, enter the **GRAPH** mode.
2. Specify the function type and input the function whose graph you want to draw.
   You can use the **GRAPH** mode to draw a graph for the following types of expressions: rectangular coordinate expression (Y=*f*(x)), polar coordinate expression, parametric function, rectangular coordinate expression (X=*f*(y)), inequality.

F3(TYPE) F1(Y=) ... rectangular coordinates (Y=*f*(x) type)

F2(r=) ... polar coordinates

F3(Parm) ... parametric function

F4(X=) ... rectangular coordinates (X=*f*(y) type)

F5(CONV) F1(►Y=) to F5(►Y≤)

F6(▷) F1(►X=) to F5(►X≤) ... changes the function type

F6(▷)F1(Y>) to F4(Y≤) .... Y inequality on left side
F6(▷)F6(▷)F1(X>) to F4(X≤) .... X inequality on left side

Repeat this step as many times as required to input all of the functions you want.

Next you should specify which of the functions among those that are stored in memory you want to graph (see page 5-6). If you do not select specific functions here, the graph operation will draw graphs of all the functions currently stored in memory.

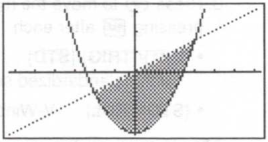
3. Draw the graph.

- You can use the function menu that appears when you press F4(STYL) in step 2 of the above procedure to select one of the following line styles for each graph.

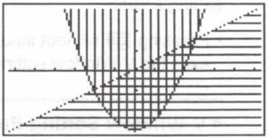
F1(—) ... Normal (initial default)
F2(━) ... Thick (twice the thickness of Normal)
F3(┅) ... Broken (thick broken)
F4(┈) ... Dot (dotted)

- When simultaneously graphing multiple inequalities, you can use the “Ineq Type” setting on the Setup screen (SHIFT MENU(SET UP)) to specify either of two fill ranges.

F1(AND) ... Fills areas only where the conditions of all of the graphed inequalities are satisfied. This is the initial default.



F2(OR) ..... Fills all areas where the conditions of the graphed inequalities are satisfied.

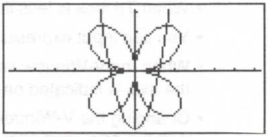


Example **Input the functions shown below and draw their graphs.**
$Y1 = 2x^2 - 3$, $r2 = 3\sin2\theta$

① MENU GRAPH

② F3(TYPE)F1(Y=) 2 X,θ,T x² − 3 EXE
F3(TYPE)F2(r=) 3 sin 2 X,θ,T EXE

③ F6(DRAW)



2. Controlling What Appears on a Graph Screen

■ V-Window (View Window) Settings

Use the View Window to specify the range of the x- and y-axes, and to set the spacing between the increments on each axis. You should always set the V-Window parameters you want to use before graphing.

• To make V-Window settings

1. From the Main Menu, enter the **GRAPH** mode.
2. Press SHIFT F3 (V-WIN) to display the V-Window setting screen.

Rectangular coordinate parameter

Xmin/Xmax … Minimum/maximum *x*-axis value

Xscale … Spacing of *x*-axis increments

Xdot … Value that corresponds to one *x*-axis dot

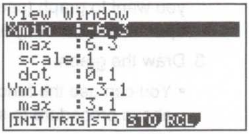
Ymin/Ymax … Minimum/maximum *y*-axis value

Yscale … Spacing of *y*-axis increments

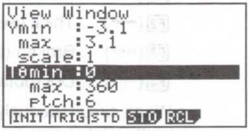
Polar coordinate parameter

Tθ min/Tθ max ... Minimum/maximum T, θ values

Tθ ptch ... T, θ pitch



```
View Window
Xmin  :-6.3
 max  :6.3
 scale:1
 dot  :0.1
Ymin  :-3.1
 max  :3.1
```



```
View Window
Ymin  :-3.1
 max  :3.1
 scale:1
Tθmin :0
  max :360
  ptch:6
```

3. Press ▼ to move the highlighting and input an appropriate value for each parameter, pressing EXE after each.
   - {**INIT**}/{**TRIG**}/{**STD**} … V-Window {initial settings}/{initial settings using specified angle unit}/{standardized settings}
   - {**STO**}/{**RCL**} … V-Window setting {store}/{recall}

After settings are the way you want them, press EXIT or SHIFT EXIT (QUIT) to exit the V-Window setting screen.

- Pressing EXE without inputting anything while ■ (busy indicator, see page iii) is displayed exits the V-Window setting screen.

• V-Window Setting Precautions

- Inputting zero for Tθ ptch causes an error.
- Any illegal input (out of range value, negative sign without a value, etc.) causes an error.
- When Tθ max is less than Tθ min, Tθ ptch becomes negative.
- You can input expressions (such as 2π) as V-Window parameters.
- When the V-Window setting produces an axis that does not fit on the display, the scale of the axis is indicated on the edge of the display closest to the origin.
- Changing the V-Window settings clears the graph currently on the display and replaces it with the new axes only.
- Changing the Xmin or Xmax value causes the Xdot value to be adjusted automatically. Changing the Xdot value causes the Xmax value to be adjusted automatically.
- A polar coordinate (*r* =) or parametric graph will appear coarse if the settings you make in the V-Window cause the Tθ ptch value to be too large, relative to the differential between the Tθ min and Tθ max settings. If the settings you make cause the Tθ ptch value to be too small relative to the differential between the Tθ min and Tθ max settings, on the other hand, the graph will take a very long time to draw.
- The following is the input range for V-Window parameters.

  –9.999999999E 97 to 9.999999999E 97

■ V-Window Memory

You can store up to six sets of V-Window settings in V-Window memory for recall when you need them.

• To store V-Window settings

1. From the Main Menu, enter the **GRAPH** mode.
2. Press SHIFT F3 (V-WIN) to display the V-Window setting screen, and input the values you want.
3. Press F4 (STO) to display the pop-up window.
4. Press a number key to specify the V-Window memory where you want to save the settings, and then press EXE. Pressing 1 EXE stores the settings in V-Window Memory 1 (V-Win1).

• To recall V-Window memory settings

1. From the Main Menu, enter the **GRAPH** mode.
2. Press SHIFT F3 (V-WIN) to display the V-Window setting screen.
3. Press F5 (RCL) to display the pop-up window.
4. Press a number key to specify the V-Window memory number for the settings you want to recall, and then press EXE. Pressing 1 EXE recalls the settings in V-Window Memory 1 (V-Win1).

■ Specifying the Graph Range

You can define a range (start point, end point) for a function before graphing it.

1. From the Main Menu, enter the **GRAPH** mode.
2. Make V-Window settings.
3. Specify the function type and input the function. The following is the syntax for function input.

   Function , SHIFT + ([ ) Start Point , End Point SHIFT − ( ])
4. Draw the graph.

Example **Graph $y = x^2 + 3x - 2$ within the range $-2 \leq x \leq 4$.**

Use the following V-Window settings.

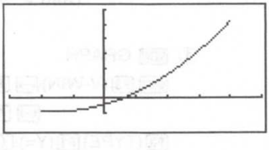
Xmin = –3, Xmax = 5, Xscale = 1
Ymin = –10, Ymax = 30, Yscale = 5

① MENU GRAPH

② SHIFT F3 (V-WIN) (−) 3 EXE 5 EXE 1 EXE ▼
(−) 1 0 EXE 3 0 EXE 5 EXE EXIT

③ F3 (TYPE) F1 (Y=) X,θ,T x² + 3 X,θ,T − 2 ,
SHIFT + ([ ) (−) 2 , 4 SHIFT − ( ]) EXE

④ F6 (DRAW)



- You can specify a range when graphing rectangular expressions, polar expressions, parametric functions, and inequalities.

■ Zoom

This function lets you enlarge and reduce the graph on the screen.

1. Draw the graph.
2. Specify the zoom type.

SHIFT F2 (ZOOM) F1 (BOX) ... Box zoom

Draw a box around a display area, and that area is enlarged to fill the entire screen.

F2 (FACT)

Specifies the *x*-axis and *y*-axis zoom factors for factor zoom.

F3 (IN)/ F4 (OUT) ... Factor zoom

The graph is enlarged or reduced in accordance with the factor you specify, centered on the current pointer location.

F5 (AUTO) ... Auto zoom

V-Window *y*-axis settings are automatically adjusted so the graph fills the screen along the *y*-axis.

F6 (▷) F1 (ORIG) ... Original size

Returns the graph to its original size following a zoom operation.

F6 (▷) F2 (SQR) ... Graph correction

V-Window *x*-axis values are corrected so they are identical to the *y*-axis values.

F6 (▷) F3 (RND) ... Coordinate rounding

Rounds the coordinate values at the current pointer location.

F6 (▷) F4 (INTG) ... Integer

Each dot is given a width of 1, which makes coordinate values integers.

F6 (▷) F5 (PRE) ... Previous

V-Window parameters are returned to what they were prior to the last zoom operation.

Box zoom range specification

3. Use the cursor keys to move the pointer (✥) in the center of the screen to the location where you want one corner of the box to be, and then press EXE.
4. Use the cursor keys to move the pointer. This causes a box to appear on the screen. Move the cursor until the area you want to enlarge is enclosed in the box, and then press EXE to enlarge it.

Example **Graph $y = (x + 5)(x + 4)(x + 3)$, and then perform a box zoom.**

Use the following V-Window settings.

Xmin = –8, Xmax = 8, Xscale = 2

Ymin = –4, Ymax = 2, Yscale = 1

① MENU GRAPH

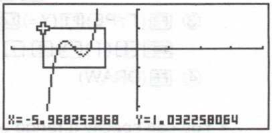
SHIFT F3 (V-WIN) (–) 8 EXE 8 EXE 2 EXE ▼

(–) 4 EXE 2 EXE 1 EXE EXIT

F3 (TYPE) F1 (Y=) (X,θ,T + 5) (X,θ,T + 4)

(X,θ,T + 3) EXE

F6 (DRAW)

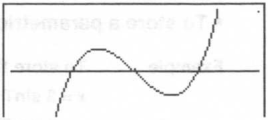


X=-5.968253968 Y=1.032258064

② SHIFT F2(ZOOM) F1(BOX)

③ ◀~◀ EXE

④ ◀~◀,▲~▲ EXE



- You must specify two different points for box zoom, and the two points cannot be on a straight line vertically or horizontally from each other.

3. Drawing a Graph

You can store up to 20 functions in memory. Functions in memory can be edited, recalled, and graphed.

Specifying the Graph Type

Before you can store a graph function in memory, you must first specify its graph type.

1. While the Graph relation list is on the display, press F3(TYPE) to display the graph type menu, which contains the following items.
   - **{Y=}**/**{r=}**/**{Parm}**/**{X=}** ... {rectangular coordinate (Y=$f(x)$ type)}/{polar coordinate}/{parametric}/{rectangular coordinate (X=$f(y)$ type)} graph
   - **{Y>}**/**{Y<}**/**{Y≥}**/**{Y≤}** ... {Y>$f(x)$}/{Y<$f(x)$}/{Y≥$f(x)$}/{Y≤$f(x)$} inequality graph
   - **{X>}**/**{X<}**/**{X≥}**/**{X≤}** ... {X>$f(y)$}/{X<$f(y)$}/{X≥$f(y)$}/{X≤$f(y)$} inequality graph
   - **{CONV}**
     - **{►Y=}**/**{►Y>}**/**{►Y<}**/**{►Y≥}**/**{►Y≤}**/**{►X=}**/**{►X>}**/**{►X<}**/**{►X≥}**/**{►X≤}** ... {changes the function type of the selected expression}
2. Press the function key that corresponds to the graph type you want to specify.

Storing Graph Functions

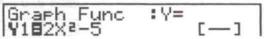
• To store a rectangular coordinate function (Y=)

Example **To store the following expression in memory area Y1: $y = 2x^2 - 5$**

F3(TYPE) F1(Y=) (Specifies rectangular coordinate expression.)

2 X,θ,T x^2 − 5 (Inputs expression.)

EXE (Stores expression.)



```
Graph Func  :Y=
Y1■2X²-5        [—]
```

- A function cannot be stored into a memory area that already contains a function of a different type from the one you are trying to store. Select a memory area that contains a function that is the same type as the one you are storing, or delete the function in the memory area to which you are trying to store.

• To store a parametric function

Example **To store the following expressions in memory areas Xt3 and Yt3:**

$x = 3\ \mathrm{sinT}$

$y = 3\ \mathrm{cosT}$

F3 (TYPE) F3 (Parm) (Specifies parametric expression.)

3 sin X,θ,T EXE (Inputs and stores *x* expression.)

3 cos X,θ,T EXE (Inputs and stores *y* expression.)

• To create a composite function

Example **To use relations in Y1 and Y2 to create composite functions for Y3 and Y4**

$\mathbf{Y1 = \sqrt{(X + 1)},\ Y2 = X^2 + 3}$

Assign Y1∘Y2 to Y3, and Y2∘Y1 to Y4.

$\mathbf{(Y1 \circ Y2 = \sqrt{((x^2 + 3) + 1)} = \sqrt{(x^2 + 4)}\quad Y2 \circ Y1 = (\sqrt{(X + 1)})^2 + 3 = X + 4\ (X \geqq -1))}$

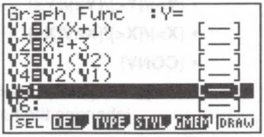
Input relations into Y3 and Y4.

F3 (TYPE) F1 (Y=) VARS F4 (GRPH)

F1 (Y) 1 (F1 (Y) 2) EXE

VARS F4 (GRPH) F1 (Y) 2

(F1 (Y) 1) EXE



```
Graph Func  :Y=
Y1■√(X+1)        [—]
Y2■X²+3          [—]
Y3■Y1(Y2)        [—]
Y4■Y2(Y1)        [—]
Y5:              [—]
Y6:              [—]
```

- A composite function can consist of up to five functions.

• To assign values to the coefficients and variables of a graph function

Example **To assign the values −1, 0, and 1 to variable A in Y = AX²−1, and draw a graph for each value**

F3 (TYPE) F1 (Y=)

ALPHA X,θ,T (A) X,θ,T x² − 1 EXE

VARS F4 (GRPH) F1 (Y) 1 (ALPHA X,θ,T (A)

SHIFT · (=) (−) 1) EXE

VARS F4 (GRPH) F1 (Y) 1 (ALPHA X,θ,T (A)

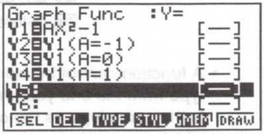
SHIFT · (=) 0) EXE

VARS F4 (GRPH) F1 (Y) 1 (ALPHA X,θ,T (A)

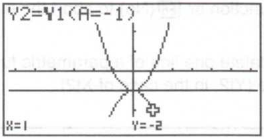
SHIFT · (=) 1) EXE

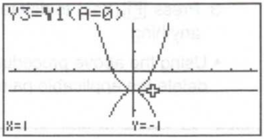
▲ ▲ ▲ ▲ F1 (SEL)

F6 (DRAW)



```
Graph Func  :Y=
Y1■AX²-1         [—]
Y2■Y1(A=-1)      [—]
Y3■Y1(A=0)       [—]
Y4■Y1(A=1)       [—]
Y5:              [—]
Y6:              [—]
```





The above three screens are produced using the Trace function.

See "Function Analysis" (page 5-28) for more information.

■ Editing and Deleting Functions

• To edit a function in memory

Example **To change the expression in memory area Y1 from $y = 2x^2 - 5$ to $y = 2x^2 - 3$**

▶ (Displays cursor.)

▶ ▶ ▶ ▶ ▶ DEL 3 (Changes contents.)

EXE (Stores new graph function.)

• To change the line style of a graph function

1. On the Graph relation list screen, use ▲ and ▼ to highlight the relation whose line style you want to change.
2. Press F4(STYL).
3. Select the line style.

Example **To change the line style of $y = 2x^2 - 3$, which is stored in area Y1, to "Broken"**

F4(STYL) F3(·····) (Selects "Broken".)

• To change the type of a function *1

1. While the Graph relation list is on the display, press ▲ or ▼ to move the highlighting to the area that contains the function whose type you want to change.
2. Press F3(TYPE) F5(CONV).
3. Select the function type you want to change to.

Example **To change the function in memory area Y1 from $y = 2x^2 - 3$ to $y < 2x^2 - 3$**

F3(TYPE) F5(CONV) F3(►Y<) (Changes the function type to "Y<".)

*1 The function type can be changed for rectangular coordinate functions and inequalities only.

• To delete a function

1. While the Graph relation list is on the display, press ▲ or ▼ to move the highlighting to the area that contains the function you want to delete.
2. Press F2(DEL) or DEL.

3. Press F1(Yes) to delete the function or F6(No) to abort the procedure without deleting anything.

- Using the above procedure to delete one line of a parametric function (such as Xt2) also will delete the applicable paired line (Yt2, in the case of Xt2).

■ Selecting Functions for Graphing

• To specify the draw/non-draw status of a graph

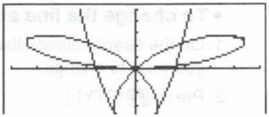
1. On the Graph relation list, use ▲ and ▼ to highlight the relation you do not want to graph.
2. Press F1(SEL).
   - Each press of F1(SEL) toggles graphing on and off.
3. Press F6(DRAW).

Example **To select the following functions for drawing:**
Y1 = $2x^2 - 5$, $r2 = 5\sin 3\theta$

Use the following V-Window settings.

Xmin = –5, **Xmax = 5,** **Xscale = 1**
Ymin = –5, **Ymax = 5,** **Yscale = 1**
Tθ min = 0, **Tθ max = π,** **Tθ ptch = 2π / 60**

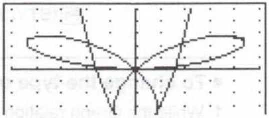
▼ ▲ (Select a memory area that contains a function for which you want to specify non-draw.)
F1(SEL) (Specifies non-draw.)
F6(DRAW) or EXE (Draws the graphs.)



- You can use the Setup screen settings to alter the appearance of the graph screen as shown below.

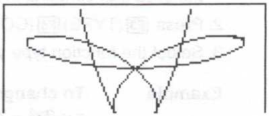
  - Grid: On (Axes: On Label: Off)

    This setting causes dots to appear at the grid intersects on the display.



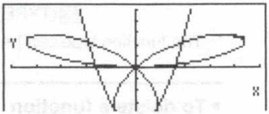
  - Axes: Off (Label: Off Grid: Off)

    This setting clears the axis lines from the display.



  - Label: On (Axes: On Grid: Off)

    This setting displays labels for the x- and y-axes.



■ Graph Memory

Graph memory lets you store up to 20 sets of graph function data and recall it later when you need it.

A single save operation saves the following data in graph memory.

- All graph functions in the currently displayed Graph relation list (up to 20)
- Graph types
- Function graph line information
- Draw/non-draw status
- V-Window settings (1 set)

• To store graph functions in graph memory

1. Press F5 (GMEM) F1 (STO) to display the pop-up window.
2. Press a number key to specify the Graph memory where you want to save the graph function, and then press EXE. Pressing 1 EXE stores the graph function to Graph Memory 1 (G-Mem1).
   - There are 20 graph memories numbered G-Mem1 to G-Mem20.
   - Storing a function in a memory area that already contains a function replaces the existing function with the new one.
   - If the data exceeds the calculator's remaining memory capacity, an error occurs.

• To recall a graph function

1. Press F5 (GMEM) F2 (RCL) to display the pop-up window.
2. Press a number key to specify the Graph memory for the function you want to recall, and then press EXE. Pressing 1 EXE recalls the graph function in Graph Memory 1 (G-Mem1).
   - Recalling data from graph memory causes any data currently on the Graph relation list to be deleted.

4. Storing a Graph in Picture Memory

You can save up to 20 graphic images in picture memory for later recall. You can overdraw the graph on the screen with another graph stored in picture memory.

• To store a graph in picture memory

1. After graphing in **GRAPH** mode, press OPTN F1 (PICT) F1 (STO) to display the pop-up window.
2. Press a number key to specify the Picture memory where you want to save the picture, and then press EXE. Pressing 1 EXE stores the picture function to Picture Memory 1 (Pict 1).
   - There are 20 picture memories numbered Pict 1 to Pict 20.
   - Storing a graphic image in a memory area that already contains a graphic image replaces the existing graphic image with the new one.
   - A dual graph screen or any other type of graph that uses a split screen cannot be saved in picture memory.

• To recall a stored graph

1. After graphing in **GRAPH** mode, press OPTN F1(PICT)F2(RCL) to display the pop-up window.
2. Press a number key to specify the Picture memory for the picture you want to recall, and then press EXE. Pressing 1 EXE recalls the picture function in Picture Memory 1 (Pict 1).
   - Recalling picture memory contents causes the currently displayed graph to be overwritten.
   - Use the sketch Cls function (page 5-27) to clear a graph that was recalled from picture memory.

5. Drawing Two Graphs on the Same Screen

■ Copying the Graph to the Sub-screen

Dual Graph lets you split the screen into two parts. Then you can graph two different functions in each for comparison, or draw a normal size graph on one side and its enlarged version on the other side. This makes Dual Graph a powerful graph analysis tool.

With Dual Graph, the left side of the screen is called the "main screen", while the right side is called the "sub-screen".

• Main Screen

The graph in the main screen is actually drawn from a function.

• Sub-screen

The graph on the sub-screen is produced by copying or zooming the main screen graph. You can even make different V-Window settings for the sub-screen and main screen.

• To copy the graph to the sub-screen

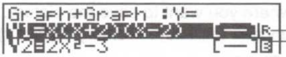
1. From the Main Menu, enter the **GRAPH** mode.
2. On the Setup screen, select "G+G" for Dual Screen.
3. Make V-Window settings for the main screen.

   Press F6(RIGHT) to display the sub-graph settings screen. Pressing F6(LEFT) returns to the main screen setting screen.
4. Store the function, and draw the graph in the main screen.
5. Perform the Dual Graph operation you want.

   OPTN F1(COPY) ... Duplicates the main screen graph in the sub-screen

   OPTN F2(SWAP) ... Swaps the main screen contents and sub-screen contents

- Indicators appear to the right of the formulas in the Graph relation list to tell where graphs are drawn with Dual Graph.



```
Graph+Graph :Y=
Y1=X(X+2)(X-2)   [—]R
Y2=2X²-3         [—]B
```

Indicates sub-screen graph (on right side of display)

Indicates graph drawn on both sides of display

Performing a draw operation with the function marked " R " in the above example screen causes the graph to be drawn on the right side on the display. The function marked " B " is drawn on both sides of the graph.

Pressing F1(SEL) while one of the function's is highlighted would causes its " R " or " B " indicator to be cleared. A function without an indicator is drawn as the main screen graph (on the left side of the display).

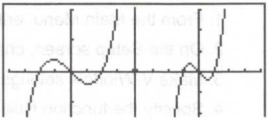
Example **Graph $y = x(x + 1)(x - 1)$ in the main screen and sub-screen.**

Use the following V-Window settings.

(Main Screen) **Xmin = –2, Xmax = 2, Xscale = 0.5**
Ymin = –2, Ymax = 2, Yscale = 1

(Sub-screen) **Xmin = –4, Xmax = 4, Xscale = 1**
Ymin = –3, Ymax = 3, Yscale = 1

① MENU GRAPH
② SHIFT MENU(SET UP) ▼ ▼ ▼ F1(G+G) EXIT
③ SHIFT F3(V-WIN) (–) 2 EXE 2 EXE 0 • 5 EXE ▼
(–) 2 EXE 2 EXE 1 EXE
F6(RIGHT) (–) 4 EXE 4 EXE 1 EXE ▼
(–) 3 EXE 3 EXE 1 EXE EXIT
④ F3(TYPE) F1(Y=) X,θ,T (X,θ,T + 1) (
X,θ,T − 1) EXE
F6(DRAW)
⑤ OPTN F1(COPY)



- Pressing AC while a graph is on the display will return to the screen in step 4.

6. Manual Graphing

■ Rectangular Coordinate Graph

Inputting the Graph command in the **RUN•MAT** mode enables drawing of rectangular coordinate graphs.

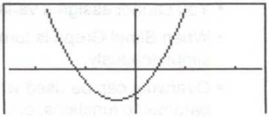
1. From the Main Menu, enter the **RUN•MAT** mode.
2. Make V-Window settings.
3. Input the commands for drawing the rectangular coordinate graph.
4. Input the function.

Example **Graph $y = 2x^2 + 3x - 4$.**

Use the following V-Window settings.

Xmin = –5, Xmax = 5, Xscale = 2
Ymin = –10, Ymax = 10, Yscale = 5

① MENU RUN•MAT
② SHIFT F3(V-WIN) (–) 5 EXE 5 EXE 2 EXE ▼
(–) 1 0 EXE 1 0 EXE 5 EXE EXIT
③ SHIFT F4(SKTCH) F1(Cls) EXE
F5(GRPH) F1(Y=)
④ 2 X,θ,T x^2 + 3 X,θ,T − 4 EXE



- Certain functions can be graphed easily using built-in function graphs.
- You can draw graphs of the following built-in scientific functions.

Rectangular Coordinate Graph

• sin x	• cos x	• tan x	• $\sin^{-1} x$
• $\cos^{-1} x$	• $\tan^{-1} x$	• sinh x	• cosh x
• tanh x	• $\sinh^{-1} x$	• $\cosh^{-1} x$	• $\tanh^{-1} x$
• $\sqrt{x}$	• x^2	• log x	• ln$x$
• 10^x	• e^x	• x^{-1}	• $\sqrt[3]{x}$
• $\frac{d}{dx}(x)$	• $\frac{d^2}{dx^2}(x)$	• $\int(x)dx$	

Polar Coordinate Graph

• sin θ	• cos θ	• tan θ	• $\sin^{-1} \theta$
• $\cos^{-1} \theta$	• $\tan^{-1} \theta$	• sinh θ	• cosh θ
• tanh θ	• $\sinh^{-1} \theta$	• $\cosh^{-1} \theta$	• $\tanh^{-1} \theta$
• $\sqrt{\theta}$	• θ^2	• log θ	• lnθ
• 10^θ	• e^θ	• θ^{-1}	• $\sqrt[3]{\theta}$

- Input for x and θ variables is not required for a built-in function.
- When inputting a built-in function, other operators or values cannot be input.

■ Drawing Multiple Graphs on the Same Screen

Use the following procedure to assign various values to a variable contained in an expression and overwrite the resulting graphs on the screen.

1. From the Main Menu, enter the **GRAPH** mode.
2. On the Setup screen, change the "Dual Screen" setting to "Off".
3. Make V-Window settings.
4. Specify the function type and input the function. The following is the syntax for function input.

   Expression containing one variable , SHIFT + ([ ) variable SHIFT . (=)

   value , value , ... , value SHIFT − ( ])
5. Draw the graph.

Example **To graph y = Ax^2 – 3 as the value of A changes in the sequence 3, 1, –1**

Use the following V-Window settings.

Xmin = –5, Xmax = 5, Xscale = 1

Ymin = –10, Ymax = 10, Yscale = 2

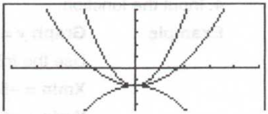
① MENU GRAPH

② SHIFT MENU (SET UP) ▼ ▼ ▼ F3 (Off) EXIT

③ SHIFT F3 (V-WIN) (−) 5 EXE 5 EXE 1 EXE ▼
(−) 1 0 EXE 1 0 EXE 2 EXE EXIT

④ F3 (TYPE) F1 (Y=) ALPHA X,θ,T (A) X,θ,T x^2 − 3 ,
SHIFT + ([ ) ALPHA X,θ,T (A) SHIFT . (=) 3 , 1 , (−) 1
SHIFT − ( ]) EXE

⑤ F6 (DRAW)



- The value of only one of the variables in the expression can change.
- Any of the following cannot be used for the variable name: X, Y, r, θ, T.
- You cannot assign a variable to the variable inside the function.
- When Simul Graph is turned on, all of the graphs for the specified variable values are drawn simultaneously.
- Overwrite can be used when graphing rectangular expressions, polar expressions, parametric functions, and inequalities.

■ Using Copy and Paste to Graph a Function

You can graph a function by copying it to the clipboard, and then pasting it into the graph screen.

There are two types of functions you can paste into the graph screen.

Type 1 (Y= expression)

A function with the Y variable to the left of the equal sign is graphed as Y= expression.

Example: To paste Y=X and graph it

- Any spaces to the left of Y are ignored.

Type 2 (expression)

Pasting this type of expression graphs Y= expression.

Example: To paste X and graph Y=X

- Any spaces to the left of the expression are ignored.

• To graph a function using copy and paste

1. Copy the function you want to graph to the clipboard.
2. From the Main Menu, enter the **GRAPH** mode.
3. On the Setup screen, change the "Dual Screen" setting to "Off".
4. Make V-Window settings.
5. Draw the graph.
6. Paste the expression.

Example **While the graph of $y = 2x^2 + 3x - 4$ is currently displayed, to paste the previously copied function Y=X from the clipboard**

Use the following V-Window settings.

Xmin = –5, Xmax = 5, Xscale = 2

Ymin = –10, Ymax = 10, Yscale = 5

① MENU RUN•MAT

ALPHA − (Y) SHIFT . (=) X,θ,T

SHIFT 8 (CLIP) ◀ ◀ ◀ F1 (COPY)

② MENU GRAPH

③ SHIFT MENU (SET UP) ▼ ▼ ▼ F3 (Off) EXIT

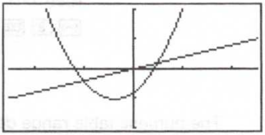
④ SHIFT F3 (V-WIN) (−) 5 EXE 5 EXE 2 EXE ▼

(−) 1 0 EXE 1 0 EXE 5 EXE EXIT

⑤ F3 (TYPE) F1 (Y=) 2 X,θ,T x^2 + 3 X,θ,T − 4 EXE

F6 (DRAW)

⑥ SHIFT 9 (PASTE)



- Paste is supported only when "Off" is selected for the "Dual Screen" setting on the Setup screen.
- Though there is no limit on the number of graphs you can draw by pasting a function, the total number of graphs supported by trace and other functions is 30 (number of graphs drawn using expression number 1 to 20, plus graphs drawn using pasted functions).

- For the graph of a pasted function, the graph expression that appears when using trace or other functions is displayed in the format: Y= expression.
- Re-executing a draw without clearing graph screen memory will redraw all the graphs, including those produced by pasting functions.

7. Using Tables

To enter the **TABLE** mode, select the **TABLE** icon on the Main Menu.

■ Storing a Function and Generating a Number Table

• To store a function

Example **To store the function $y = 3x^2 - 2$ in memory area Y1**

Use ▲ and ▼ to move the highlighting in the Table relation list to the memory area where you want to store the function. Next, input the function and press EXE to store it.

• Variable Specifications

There are two methods you can use to specify value for the variable *x* when generating a numeric table.

- **Table range method**

  With this method, you specify the conditions for the change in value of the variable.
- **List**

  With this method, the data in the list you specify is substituted for the *x*-variable to generate a number table.

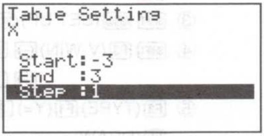
• To generate a table using a table range

Example **To generate a table as the value of variable *x* changes from –3 to 3, in increments of 1**

MENU TABLE

F5(SET)

(−) 3 EXE 3 EXE 1 EXE



```
Table Setting
X

 Start:-3
 End  :3
 Step :1
```

The numeric table range defines the conditions under which the value of variable *x* changes during function calculation.

Start .... Variable *x* start value

End .... Variable *x* end value

Step .... Variable *x* value change (interval)

After specifying the table range, press EXIT to return to the Table relation list.

• To generate a table using a list

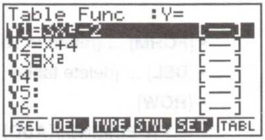
1. While the Table relation list is on the screen, display the Setup screen.
2. Highlight Variable and then press F2(LIST) to display the pop-up window.
3. Select the list whose values you want to assign for the *x*-variable.
   - To select List 6, for example, press 6 EXE. This causes the setting of the Variable item of the Setup screen to change to List 6.
4. After specifying the list you want to use, press EXIT to return to the previous screen.

• Generating a Table

Example **To generate a table of values for the functions stored in memory areas Y1 and Y3 of the Table relation list**

Use ▲ and ▼ to move the highlighting to the function you want to select for table generation and press F1(SEL) to select it.

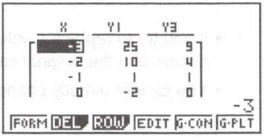
The "=" sign of selected functions is highlighted on the screen. To deselect a function, move the cursor to it and press F1(SEL) again.



```
Table Func  :Y=
Y1=3X²-2            [—]
Y2=X+4              [—]
Y3=X²               [—]
Y4:                 [—]
Y5:                 [—]
Y6:                 [—]
```

Press F6(TABL) to generate a number table using the functions you selected. The value of variable *x* changes according to the range or the contents of the list you specified.

The example screen shown here shows the results based on the contents of List 6 (–3, –2, –1, 0, 1, 2, 3).



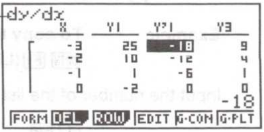
X	Y1	Y3
-3	25	9
-2	10	4
-1	1	1
0	-2	0

-3

Each cell can contain up to six digits, including negative sign.

• To generate a differential number table

Changing the setting of Setup screen's Derivative item to On causes a number table that includes the derivative to be displayed whenever you generate a number table.



Locating the cursor at a differential coefficient displays "dy/dx" in the top line, which indicates differential.

dy/dx

X	Y1	Y'1	Y3
-3	25	-18	9
-2	10	-12	4
-1	1	-6	1
0	-2	0	0

-18

- An error occurs if a graph for which a range is specified or an overwrite graph is included among the graph expressions.

• Specifying the Function Type

You can specify a function as being one of three types.

- Rectangular coordinate (Y=)
- Polar coordinate (*r*=)
- Parametric (Parm)

1. Press F3(TYPE) while the relation list is on the screen.

2. Press the number key that corresponds to the function type you want to specify.

- The number table is generated only for the function type specified on the relation list (Table Func). You cannot generate a number table for a mixture of different function types.

Editing Tables

You can use the table menu to perform any of the following operations once you generate a table.

- Change the values of variable *x*
- Edit (delete, insert, and append) rows
- Delete a table
- Draw a connect type graph
- Draw a plot type graph

- {**FORM**} ... {return to Table relation list}
- {**DEL**} ... {delete table}
- {**ROW**}
  - {**DEL**}/{**INS**}/{**ADD**} ... {delete}/{insert}/{add} row
- {**G•CON**}/{**G•PLT**} ... {connected type}/{draw plot type} graph draw

- If you try to replace a value with an illegal operation (such as division by zero), an error occurs and the original value remains unchanged.
- You cannot directly change any values in the other (non-*x*) columns of the table.

Copying a Table Column to a List

A simple operation lets you copy the contents of a numeric table column into a list.

Use ◀ and ▶ to move the cursor to the column you want to copy. The cursor can be in any row.

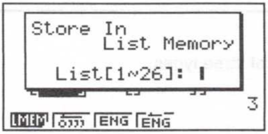
• To copy a table to a list

Example **To copy the contents of Column *x* into List 1**

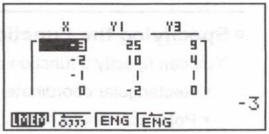
OPTN F1(LMEM)

Input the number of the list you want to copy and then press EXE.

1 EXE



```
Store In
     List Memory

  List[1~26]: ▌
                    3
```



```
     X      Y1     Y3
    -3      25      9
    -2      10      4
    -1       1      1
     0      -2      0
                        -3
```

■ Drawing a Graph from a Number Table

Use the following procedure to generate a number table and then draw a graph based on the values in the table.

1. From the Main Menu, enter the **TABLE** mode.
2. Make V-Window settings.
3. Store the functions.
4. Specify the table range.
5. Generate the table.
6. Select the graph type and draw it.

   F5(G • CON) ... line graph

   F6(G • PLT) ... plot type graph

- After drawing the graph, pressing SHIFT F6(G ↔ T) or AC returns to the number table screen.

Example **Store the two functions below, generate a number table, and then draw a line graph. Specify a range of –3 to 3, and an increment of 1.**

$Y1 = 3x^2 - 2$, $Y2 = x^2$

Use the following V-Window settings.

Xmin = 0, **Xmax = 6,** **Xscale = 1**

Ymin = –2, **Ymax = 10,** **Yscale = 2**

① MENU TABLE

② SHIFT F3(V-WIN) 0 EXE 6 EXE 1 EXE ▼

(–) 2 EXE 1 0 EXE 2 EXE EXIT

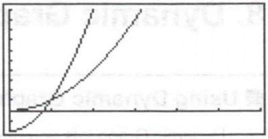
③ F3(TYPE) F1(Y=) 3 X,θ,T x^2 – 2 EXE

X,θ,T x^2 EXE

④ F5(SET) (–) 3 EXE 3 EXE 1 EXE EXIT

⑤ F6(TABL)

⑥ F5(G • CON)



- You can use Trace, Zoom, or Sketch after drawing a graph.

■ Simultaneously Displaying a Number Table and Graph

Specifying T+G for Dual Screen on the Setup screen makes it possible to display a number table and graph at the same time.

1. From the Main Menu, enter the **TABLE** mode.
2. Make V-Window settings.
3. On the Setup screen, select T+G for Dual Screen.
4. Input the function.
5. Specify the table range.
6. The number table is displayed in the sub-screen on the right.

7. Specify the graph type and draw the graph.

   F5 (G • CON) ... line graph

   F6 (G • PLT) ... plot type graph

Example **Store the function Y1 = $3x^2 - 2$ and simultaneously display its number table and line graph. Use a table range of –3 to 3 with an increment of 1.**

Use the following V-Window settings.

Xmin = 0, Xmax = 6, Xscale = 1

Ymin = –2, Ymax = 10, Yscale = 2

① MENU TABLE

② SHIFT F3 (V-WIN) 0 EXE 6 EXE 1 EXE ▼

(–) 2 EXE 1 0 EXE 2 EXE EXIT

③ SHIFT MENU (SET UP) ▼ ▼ F1 (T+G) EXIT

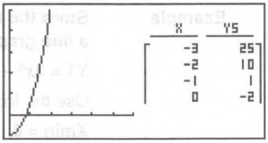
④ F3 (TYPE) F1 (Y=) 3 X,θ,T x^2 – 2 EXE

⑤ F5 (SET)

(–) 3 EXE 3 EXE 1 EXE EXIT

⑥ F6 (TABL)

⑦ F5 (G • CON)



X	Y5
-3	25
-2	10
-1	1
0	-2

- The Setup screen's "Dual Screen" setting is applied in the **TABLE** mode and the **RECUR** mode.
- You can make the number table active by pressing OPTN F1 (CHNG) or AC.

8. Dynamic Graphing

■ Using Dynamic Graph

Dynamic Graph lets you define a range of values for the coefficients in a function, and then observe how a graph is affected by changes in the value of a coefficient. It helps to see how the coefficients and terms that make up a function influence the shape and position of a graph.

1. From the Main Menu, enter the **DYNA** mode.
2. Make V-Window settings.
3. On the Setup screen, specify the Dynamic Type.

   F1 (Cnt) ... Continuous

   F2 (Stop) ... Automatic stop after 10 draws
4. Use the cursor keys to select the function type on the built-in function type list.*1
5. Input values for coefficients, and specify which coefficient will be the dynamic variable.*2
6. Specify the start value, end value, and increment.
7. Specify the drawing speed.

   F3 (SPEED) F1 (II▷).... Pause after each draw (Stop&Go)
   F2 (▷)...... Half normal speed (Slow)
   F3 (▶)...... Normal speed (Normal)
   F4 (≫)..... Twice normal speed (Fast)

8. Draw the Dynamic Graph.

*1 The following are the seven built-in function types.

- $Y=AX+B$
- $Y=A(X+B)^2+C$
- $Y=AX^2+BX+C$
- $Y=AX\text{\^{}}3+BX^2+CX+D$
- $Y=A\sin(BX+C)$
- $Y=A\cos(BX+C)$
- $Y=A\tan(BX+C)$

After you press [F3](TYPE) and select the function type you want, you can then input the actual function.

*2 You could also press [EXE] here and display the parameter setting menu.

- The message "Too Many Functions" appears when more than one function is selected for Dynamic Graphing.

Example **Use Dynamic Graph to graph $y = A(x-1)^2-1$, in which the value of coefficient A changes from 2 through 5 in increments of 1. The graph is drawn 10 times.**

① [MENU] DYNA

② [SHIFT] [F3](V-WIN) [F1](INIT) [EXIT]

③ [SHIFT] [MENU](SET UP) [F2](Stop) [EXIT]

④ [F5](B-IN) [▼] [F1](SEL)

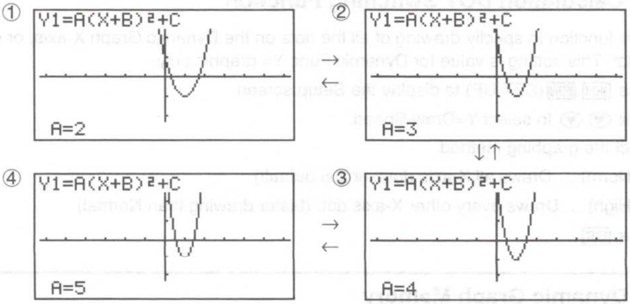
⑤ [F4](VAR) [2] [EXE] [(–)] [1] [EXE] [(–)] [1] [EXE]

⑥ [F2](SET) [2] [EXE] [5] [EXE] [1] [EXE] [EXIT]

⑦ [F3](SPEED) [F3](▶) [EXIT]

⑧ [F6](DYNA)

Repeats from ① through ④.



①
$Y1=A(X+B)^2+C$
A=2

②
$Y1=A(X+B)^2+C$
A=3

③
$Y1=A(X+B)^2+C$
A=4

④
$Y1=A(X+B)^2+C$
A=5

■ Drawing a Dynamic Graph Locus

Turning on the Dynamic Graph locus setting on the Setup screen lets you overlay a graph drawn by changing the coefficient values.

1. From the Main Menu, enter the **DYNA** mode.
2. Make V-Window settings.
3. On the Setup screen, select "On" for "Locus".
4. Use the cursor keys to select the function type on the built-in function type list.
5. Input values for coefficients, and specify which coefficient will be the dynamic variable.

6. Specify the start value, end value, and increment.
7. Specify Normal for the draw speed.
8. Draw the Dynamic Graph.

Example **Use Dynamic Graph to graph $y = Ax$, in which the value of coefficient A changes from 1 through 4 in increments of 1. The Graph is drawn 10 times.**

① MENU DYNA

② SHIFT F3(V-WIN) F1(INIT) EXIT

③ SHIFT MENU(SET UP) ▼ F1(On) EXIT

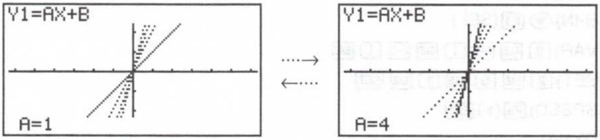
④ F5(B-IN) F1(SEL)

⑤ F4(VAR) 1 EXE 0 EXE

⑥ F2(SET) 1 EXE 4 EXE 1 EXE EXIT

⑦ F3(SPEED) F3(▸) EXIT

⑧ F6(DYNA)



■ Graph Calculation DOT Switching Function

Use this function to specify drawing of all the dots on the Dynamic Graph X-axis, or every other dot. This setting is value for Dynamic Func Y= graphic only.

1. Press SHIFT MENU(SET UP) to display the Setup screen.
2. Press ▼ ▼ to select Y=Draw Speed.
3. Select the graphing method.

   F1(Norm) … Draws all X-axis dots. (initial default)

   F2(High) … Draws every other X-axis dot. (faster drawing than Normal)
4. Press EXIT.

■ Using Dynamic Graph Memory

You can store Dynamic Graph conditions and screen data in Dynamic Graph memory for later recall when you need it. This lets you save time, because you can recall the data and immediately begin a Dynamic Graph draw operation. Note that you can store one set of data in memory at any one time.

• To save data in Dynamic Graph memory

1. While a Dynamic Graph draw operation is being performed, press AC to change to the speed adjustment menu.
2. Press F5(STO). In response to the confirmation dialog that appears, press F1(Yes) to save the data.

• To recall data from Dynamic Graph memory

1. Display the Dynamic Graph relation list.
2. Pressing F6 (RCL) recalls Dynamic Graph memory contents and draws the graph.

9. Graphing a Recursion Formula

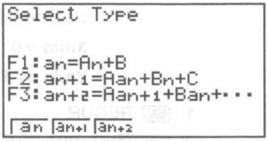
■ Generating a Number Table from a Recursion Formula

You can input up to three of the following types of recursion formulas and generate a number table.

- General term of sequence $\{a_n\}$, composed of a_n, n
- Linear two-term recursion composed of a_{n+1}, a_n, n
- Linear three-term recursion composed of a_{n+2}, a_{n+1}, a_n, n

1. From the Main Menu, enter the **RECUR** mode.
2. Specify the recursion type.

   F3 (TYPE) F1 (a_n) ... {general term of sequence a_n}
   F2 (a_{n+1}) ... {linear two-term recursion}
   F3 (a_{n+2}) ... {linear three-term recursion}



```
Select Type

F1:an=An+B
F2:an+1=Aan+Bn+C
F3:an+2=Aan+1+Ban+···
```

3. Input the recursion formula.
4. Specify the table range. Specify a start point and end point for n. If necessary, specify a value for the initial term, and a pointer start point value if you plan to graph the formula.
5. Display the recursion formula number table.

Example **Generate a number table from recursion between three terms as expressed by $a_{n+2} = a_{n+1} + a_n$, with initial terms of $a_1 = 1$, $a_2 = 1$ (Fibonacci sequence), as n changes in value from 1 to 6.**

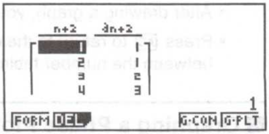
① MENU RECUR

② F3 (TYPE) F3 (a_{n+2})

③ F4 ($n.a_n$ ··) F3 (a_{n+1}) + F2 (a_n) EXE

④ F5 (SET) F2 (a_1) 1 EXE 6 EXE 1 EXE 1 EXE EXIT

⑤ F6 (TABL)



n+2	an+2
1	1
2	1
3	2
4	3

* The first two values correspond to $a_1 = 1$ and $a_2 = 1$.

- Pressing F1 (FORM) will return to the screen for storing recursion formulas.
- Specifying "On" for the "ΣDisplay" of the Setup screen causes the sum of each term to be included in the table.

■ Graphing a Recursion Formula

After generating a number table from a recursion formula, you can graph the values on a line graph or plot type graph.

1. From the Main Menu, enter the **RECUR** mode.
2. Make V-Window settings.
3. Specify the recursion formula type and input the formula.
4. Specify the table range, and start and ending values for n. If necessary, specify the initial term value and pointer start point.
5. Select the line style for the graph.
6. Display the recursion formula number table.
7. Specify the graph type and draw the graph.

   F5(G•CON) ... line graph

   F6(G•PLT) ... plot type graph

Example **Generate a number table from recursion between two terms as expressed by $a_{n+1} = 2a_n + 1$, with an initial term of $a_1 = 1$, as n changes in value from 1 to 6. Use the table values to draw a line graph.**

Use the following V-Window settings.

Xmin = 0, Xmax = 6, Xscale = 1

Ymin = –15, Ymax = 65, Yscale = 5

① MENU RECUR

② SHIFT F3(V-WIN) 0 EXE 6 EXE 1 EXE ▼
(–) 1 5 EXE 6 5 EXE 5 EXE EXIT

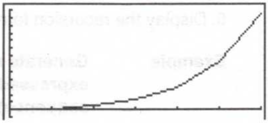
③ F3(TYPE) F2(a_{n+1}) 2 F2(a_n) + 1 EXE

④ F5(SET) F2(a_1) 1 EXE 6 EXE 1 EXE EXIT

⑤ F1(SEL+S) ▲ F2(—) EXIT

⑥ F6(TABL)

⑦ F5(G•CON)



- After drawing a graph, you can use Trace, Zoom, and Sketch.
- Press AC to return to the number table screen. After drawing a graph, you can toggle between the number table screen and graph screen by pressing SHIFT F6 (G↔T).

■ Graphing a Phase Plot from Two Numeric Sequences

You can draw the phase plot for numeric sequences generated by two expressions input in the **RECUR** mode with one value on the horizontal axis and the other value on the vertical axis. For a_n (a_{n+1}, a_{n+2}), b_n (b_{n+1}, b_{n+2}), c_n (c_{n+1}, c_{n+2}), the numeric sequence of the alphabetically first expression is on the horizontal axis while the following numeric sequence is on the vertical axis.

1. From the Main Menu, enter the **RECUR** mode.
2. Configure V-Window settings.
3. Enter two recursion formulas and select both of them for table generation.

4. Configure table generation settings.

   Specify the start and end values for variable *n* and the initial term for each recursion formula.

5. Display the recursion formula number table.
6. Draw the phase plot.

Example **To input the two sequence formulas for regression between two terms $a_{n+1} = 0.9a_n$ and $b_{n+1} = b_n + 0.1_n - 0.2$, and specify initial terms $a_1 = 1$ and $b_1 = 1$ for each. Generate a number table as the value of the *n* variable goes from 1 to 10 and use it to draw a phase plot.**

Use the following V-Window settings.

Xmin = 0, Xmax = 2, Xscale = 1

Ymin = 0, Ymax = 4, Yscale = 1

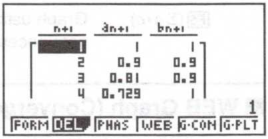
① MENU RECUR

② SHIFT F3 (V-WIN) 0 EXE 2 EXE 1 EXE ▼
0 EXE 4 EXE 1 EXE EXIT

③ F3 (TYPE) F2 (a_{n+1}) 0 · 9 F2 (a_n) EXE
F4 ($n.a_n$ ··) F3 (b_n) + 0 · 1 F1 (n) − 0 · 2 EXE

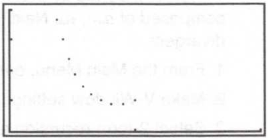
④ F5 (SET) F2 (a_1) 1 EXE 1 0 EXE 1 EXE 1 EXE EXIT

⑤ F6 (TABL)



```
     n+1      an+1     bn+1
        1        1        1
        2      0.9      0.9
        3     0.81      0.9
        4    0.729        1
```

⑥ F3 (PHAS)

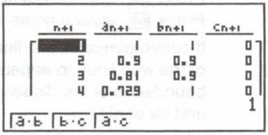


- If you enter three expressions on the **RECUR** mode screen and select all of them for table creation, you will need to specify which two of the three expressions you want to use to draw the phase plot. To do so, use the function menu that appears when you press F3 (PHAS) on the table screen.

  F1 (a•b).......... Graph using a_n (a_{n+1}, a_{n+2}) and b_n (b_{n+1}, b_{n+2}).

  F2 (b•c).......... Graph using b_n (b_{n+1}, b_{n+2}) and c_n (c_{n+1}, c_{n+2}).

  F3 (a•c).......... Graph using a_n (a_{n+1}, a_{n+2}) and c_n (c_{n+1}, c_{n+2}).

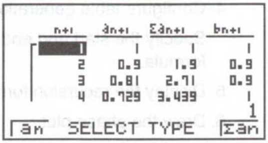


```
     n+1      an+1     bn+1     cn+1
        1        1        1        0
        2      0.9      0.9        0
        3     0.81      0.9        0
        4    0.729        1        0
```

- Specifying "On" for the "ΣDisplay" of the Setup screen causes the sum of each term to be included in the table. At this time you can select use of the two numeric sequences as-is to draw the plot graph, or use of the sums of each of the two numeric sequences. To do so, use the function menu that appears when you press F3 (PHAS) on the table screen.

F1 (a_n) ....Use numeric sequence for graphing.

F6 (Σa_n).........Use numeric sequence sums for graphing.



n+1	a_{n+1}	Σa_{n+1}	b_{n+1}
1	1	1	1
2	0.9	1.9	0.9
3	0.81	2.71	0.9
4	0.729	3.439	1

- When "On" is selected "ΣDisplay" on the Setup screen and all three of the expressions you input in the **RECUR** mode are selected for table creation, use the function menu that appears when you press F3 (PHAS) on the table screen to specify which two of the expressions you want to use, and to specify whether you want to use numeric sequence data or numeric sequence sum data.

F1 ($a \bullet b$)..........Graph using number sequences a_n (a_{n+1}, a_{n+2}) and b_n (b_{n+1}, b_{n+2})

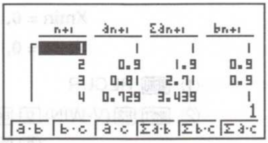
F2 ($b \bullet c$)..........Graph using number sequences b_n (b_{n+1}, b_{n+2}) and c_n (c_{n+1}, c_{n+2})

F3 ($a \bullet c$)..........Graph using number sequences a_n (a_{n+1}, a_{n+2}) and c_n (c_{n+1}, c_{n+2})

F4 ($\Sigma a \bullet b$).......Graph using the sums of number sequences a_n (a_{n+1}, a_{n+2}) and b_n (b_{n+1}, b_{n+2})

F5 ($\Sigma b \bullet c$).......Graph using the sums of number sequences b_n (b_{n+1}, b_{n+2}) and c_n (c_{n+1}, c_{n+2})

F6 ($\Sigma a \bullet c$).......Graph using the sums of number sequences a_n (a_{n+1}, a_{n+2}) and c_n (c_{n+1}, c_{n+2})



n+1	a_{n+1}	Σa_{n+1}	b_{n+1}
1	1	1	1
2	0.9	1.9	0.9
3	0.81	2.71	0.9
4	0.729	3.439	1

WEB Graph (Convergence, Divergence)

$y = f(x)$ is graphed by presuming $a_{n+1} = y$, $a_n = x$ for linear two-term regression $a_{n+1} = f(a_n)$ composed of a_{n+1}, a_n. Next, it can be determined whether the function is convergent or divergent.

1. From the Main Menu, enter the **RECUR** mode.
2. Make V-Window settings.
3. Select 2-term recursion as the recursion formula type, and input the formula.
4. Specify the table range, n start and end points, initial term value, and pointer start point.
5. Display the recursion formula number table.
6. Draw the graph.
7. Press EXE, and the pointer appears at the start point you specified.
   Press EXE several times.

   If convergence exists, lines that resemble a spider web are drawn on the display. Failure of the web lines to appear indicates either divergence or that the graph is outside the boundaries of the display screen. When this happens, change to larger V-Window values and try again.

   You can use ⊙⊙ to select the graph.

Example **To draw the WEB graph for the recursion formula $a_{n+1} = -3(a_n)^2 + 3a_n$, $b_{n+1} = 3b_n + 0.2$, and check for divergence or convergence. Use the following table range: Start = 0, End = 6, a_0 = 0.01, a_nStr = 0.01, b_0 = 0.11, b_nStr = 0.11**

① MENU RECUR

② SHIFT F3 (V-WIN) 0 EXE 1 EXE 1 EXE ▼
0 EXE 1 EXE 1 EXE EXIT

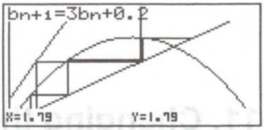
③ F3 (TYPE) F2 (a_{n+1}) (-) 3 F2 (a_n) x^2 + 3 F2 (a_n) EXE
3 F3 (b_n) + 0 · 2 EXE

④ F5 (SET) F1 (a_0)
0 EXE 6 EXE 0 · 0 1 EXE 0 · 1 1 EXE ▼
0 · 0 1 EXE 0 · 1 1 EXE EXIT

⑤ F6 (TABL)

⑥ F4 (WEB)

⑦ EXE ~ EXE (a_n is convergence)
▼ EXE ~ EXE (b_n is divergence)



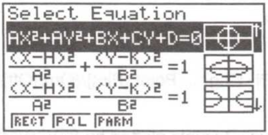
- To change the graph line style, press F1 (SEL+S) after step 4.
- With WEB Graph, you can specify the line type for a $y = f(x)$ graph. The line type setting is valid only when "Connect" is selected for "Draw Type" on the Setup screen.

10. Graphing a Conic Section

Graphing a Conic Section

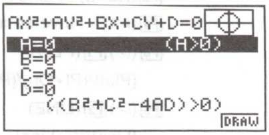
You can use the **CONICS** mode to graph parabolas, circles, ellipses, and hyperbolas. You can input a rectangular coordinate function, polar coordinate function, or parametric function for graphing.

1. From the Main Menu, enter the **CONICS** mode.
2. Select the function type.
   F1 (RECT).... {rectangular coordinate}
   F2 (POL).... {polar coordinate}
   F3 (PARM).... {parametric}
3. Select the pattern of the function in accordance with the type of graph you want to draw.



Select Equation
AX²+AY²+BX+CY+D=0
$\frac{(X-H)^2}{A^2}+\frac{(Y-K)^2}{B^2}=1$
$\frac{(X-H)^2}{A^2}-\frac{(Y-K)^2}{B^2}=1$

→ EXE



AX²+AY²+BX+CY+D=0
A=0 (A>0)
B=0
C=0
D=0
((B²+C²-4AD)>0)

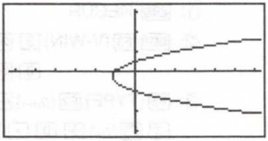
4. Enter the coefficients of the function and draw the graph.

Example **To input the rectangular coordinate function $x = 2y^2 + y - 1$ and graph a parabola open on the right, and then input the polar coordinate function $r = 4\cos\theta$ and draw a circle graph.**

① MENU CONICS

② F1(RECT) ▼ (X=AY²+BY+C) EXE

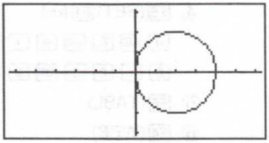
③ 2 EXE 1 EXE (−) 1 EXE F6(DRAW)



④ EXIT EXIT

⑤ F2(POL) ▼ ▼ ▼ ▼ (R=2Acosθ) EXE

⑥ 2 EXE F6(DRAW)



11. Changing the Appearance of a Graph

■ Drawing a Line

The sketch function lets you draw points and lines inside of graphs.
You can select one of four different line styles for drawing with the sketch function.

1. From the Main Menu, enter the **GRAPH** mode.
2. Make V-Window settings.
3. On the Setup screen, use the “Sketch Line” setting to specify the line style you want.

   F1(—) … Normal (initial default)

   F2(**—**) … Thick (twice the thickness of Normal)

   F3(•••••) … Broken (thick broken)

   F4(.......) … Dot (dotted)
4. Input the function of the graph.
5. Draw the graph.
6. Select the sketch function you want to use.*1

   SHIFT F4(SKTCH) F1(Cls) ... Screen clear

   F2(Tang) ... Tangent line

   F3(Norm) ... Line normal to a curve

   F4(Inv) ... Inverse function*2

   F6(▷) F1(PLOT)

   {Plot}/{Pl • On}/{Pl • Off}/{Pl • Chg} ... Point {Plot}/{On}/{Off}/{Change}

   F6(▷) F2(LINE)

   {Line}/{F • Line} ... {connects 2 points plotted by F6(▷) F1(PLOT) with a line}/{for drawing a line between any 2 points}

   F6(▷) F3(Crcl) ... Circle

   F6(▷) F4(Vert) ... Vertical line

   F6(▷) F5(Hztl) ... Horizontal line

   F6(▷) F6(▷) F1(PEN) ... Freehand

   F6(▷) F6(▷) F2(Text) ... Text input

7. Use the cursor keys to move the pointer (✛) to the location where you want to draw, and press EXE.*3

*1 The above shows the function menu that appears in the **GRAPH** mode. Menu items may differ somewhat in other modes.

*2 In the case of an inverse function graph, drawing starts immediately after you select this option.

*3 Some sketch functions require specification of two points. After you press EXE to specify the first point, use the cursor keys to move the pointer to the location of the second point and press EXE.

- You can specify line type for the following sketch functions: Tangent, Normal, Inverse, Line, F•Line, Circle, Vertical, Horizontal, Pen

Example **Draw a line that is tangent to point (2, 0) on the graph for $y = x(x + 2)(x - 2)$.**

① MENU GRAPH

② SHIFT F3(V-WIN) F1(INIT) EXIT

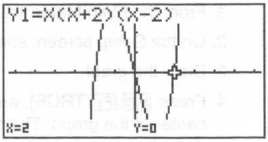
③ SHIFT MENU(SET UP) ▼ ▼ ▼ ▼ ▼ ▼ ▼ F1(—) EXIT

④ F3(TYPE) F1(Y=) X,θ,T (X,θ,T + 2) (X,θ,T
− 2) EXE

⑤ F6(DRAW)

⑥ SHIFT F4(SKTCH) F2(Tang)

⑦ ▶ ~ ▶ EXE *1



```
Y1=X(X+2)(X-2)
X=2         Y=0
```

*1 You can draw a tangent line in succession by moving the "✛" pointer and pressing EXE.

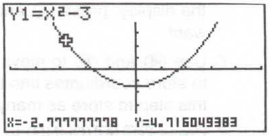
12. Function Analysis

■ Reading Coordinates on a Graph Line

Trace lets you move a pointer along a graph and read out coordinates on the display.

1. From the Main Menu, enter the **GRAPH** mode.
2. Draw the graph.
3. Press SHIFT F1(TRCE), and a pointer appears in the center of the graph.*1
4. Use ◀ and ▶ to move the pointer along the graph to the point at which you want to display the derivative.

   When there are multiple graphs on the display, press ▲ and ▼ to move between them along the x-axis of the current pointer location.



```
Y1=X²-3
X=-2.777777778  Y=4.716049383
```

5. You can also move the pointer by pressing X,θ,T to display the pop-up window, and then inputting coordinates.

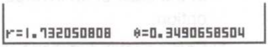
   The pop-up window appears even when you input coordinates directly.

To exit a trace operation, press SHIFT F1(TRCE).

[1] The pointer is not visible on the graph when it is located at a point outside the graph display area or when an error of no value occurs.

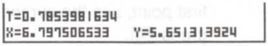
- You can turn off display of the coordinates at the pointer location by specifying "Off" for the "Coord" item on the Setup screen.
- The following shows how coordinates are displayed for each function type.

Polar Coordinate Graph



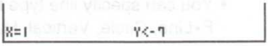
```
r=1.732050808   θ=0.3490658504
```

Parametric Graph



```
T=0.7853981634
X=6.797506533   Y=5.651313924
```

Inequality Graph

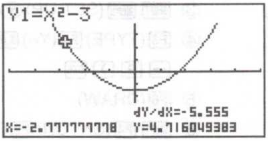


```
X=1             Y<-7
```

Displaying the Derivative

In addition to using Trace to display coordinates, you can also display the derivative at the current pointer location.

1. From the Main Menu, enter the **GRAPH** mode.
2. On the Setup screen, specify On for Derivative.
3. Draw the graph.
4. Press SHIFT F1(TRCE), and the pointer appears at the center of the graph. The current coordinates and the derivative also appear on the display at this time.

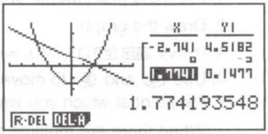


```
Y1=X²-3
                dY/dX=-5.555
X=-2.777777778  Y=4.716049383
```

Graph to Table

You can use trace to read the coordinates of a graph and store them in a number table. You can also use Dual Graph to simultaneously store the graph and number table, making this an important graph analysis tool.

1. From the Main Menu, enter the **GRAPH** mode.
2. On the Setup screen, specify GtoT for Dual Screen.
3. Make V-Window settings.
4. Save the function and draw the graph on the main (left) screen.
5. Activate Trace. When there are multiple graphs on the display, press ▲ and ▼ to select the graph you want.
6. Use ◀ and ▶ to move the pointer and press EXE to store coordinates into the number table. Repeat this step to store as many values as you want.
7. Press OPTN F1(CHNG) to make the number table active.



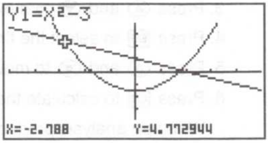
```
   X        Y1
-2.741   4.5182
     0       -3
1.7741   0.1477
1.774193548
```

Coordinate Rounding

This function rounds off coordinate values displayed by Trace.

1. From the Main Menu, enter the **GRAPH** mode.
2. Draw the graph.

3. Press SHIFT F2(ZOOM) F6(▷) F3(RND). This causes the V-Window settings to be changed automatically in accordance with the Rnd value.
4. Press SHIFT F1(TRCE), and then use the cursor keys to move the pointer along the graph. The coordinates that now appear are rounded.



```
Y1=X²-3
X=-2.788          Y=4.772944
```

■ Calculating the Root

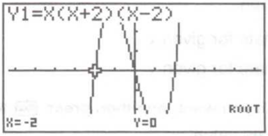
This feature provides a number of different methods for analyzing graphs.

1. From the Main Menu, enter the **GRAPH** mode.
2. Draw the graphs.
3. Select the analysis function.

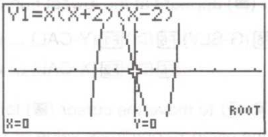
SHIFT F5(G-SLV) F1(ROOT) ... Calculation of root
F2(MAX) ... Local maximum value
F3(MIN) ... Local minimum value
F4(Y-ICPT) ... *y*-intercept
F5(ISCT) ... Intersection of two graphs
F6(▷) F1(Y-CAL) ... *y*-coordinate for given *x*-coordinate
F6(▷) F2(X-CAL) ... *x*-coordinate for given *y*-coordinate
F6(▷) F3(∫*dx*) ... Integral value for a given range

4. When there are multiple graphs on the screen, the selection cursor (■) is located at the lowest numbered graph. Press ▲ and ▼ to move the cursor to the graph you want to select.
5. Press EXE to select the graph where the cursor is located and display the value produced by the analysis.

   When an analysis produces multiple values, press ▶ to calculate the next value. Pressing ◀ returns to the previous value.



```
Y1=X(X+2)(X-2)
                          ROOT
X=-2          Y=0
```



```
Y1=X(X+2)(X-2)
                          ROOT
X=0           Y=0
```

- Either of the following can cause poor accuracy or even make it impossible to obtain solutions.
  - When the graph of the solution obtained is a point of tangency with the *x*-axis
  - When a solution is an inflection point

■ Calculating the Point of Intersection of Two Graphs

Use the following procedure to calculate the point of intersection of two graphs.

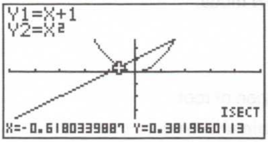
1. Draw the graphs.
2. Press SHIFT F5(G-SLV) F5(ISCT). When there are three or more graphs, the selection cursor (■) appears at the lowest numbered graph.

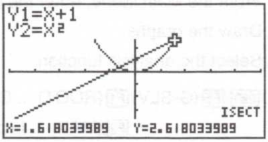
3. Press ▲ and ▼ to move the cursor to the graph you want to select.
4. Press EXE to select the first graph, which changes the shape of the cursor from ■ to ◆.
5. Press ▲ and ▼ to move the cursor to the second graph.
6. Press EXE to calculate the point of intersection for the two graphs.

   When an analysis produces multiple values, press ▶ to calculate the next value. Pressing ◀ returns to the previous value.

Example **Graph the two functions shown below, and determine the point of intersection between Y1 and Y2.**

Y1 = x + 1, Y2 = x^2





- You can calculate the point of intersection for rectangular coordinate graphs (Y=$f(x)$ type) and inequality graphs (Y>$f(x)$, Y<$f(x)$, Y≥$f(x)$ or Y≤$f(x)$) only.
- Either of the following can cause poor accuracy or even make it impossible to obtain solutions.
  - When a solution is a point of tangency between two graphs
  - When a solution is an inflection point

■ Determining the Coordinates for Given Points

The following procedure describes how to determine the y-coordinate for a given x, and the x-coordinate for a given y.

1. Draw the graph.
2. Select the function you want to perform. When there are multiple graphs, the selection cursor (■) appears at the lowest numbered graph.

   SHIFT F5 (G-SLV) F6 (▷) F1 (Y-CAL) ... y-coordinate for given x

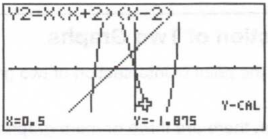
   F6 (▷) F2 (X-CAL) ... x-coordinate for given y

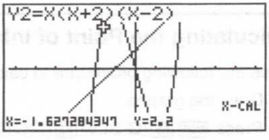
3. Use ▲ ▼ to move the cursor (■) to the graph you want, and then press EXE to select it.
4. Input the given x-coordinate value or y-coordinate value.

   Press EXE to calculate the corresponding y-coordinate value or x-coordinate value.

Example **Graph the two functions shown below and then determine the y-coordinate for x = 0.5 and the x-coordinate for y = 2.2 on graph Y2.**

Y1 = x + 1, Y2 = $x(x + 2)(x - 2)$





- When there are multiple results for the above procedure, press ▶ to calculate the next value. Pressing ◀ returns to the previous value.
- The X-CAL value cannot be obtained for a parametric function graph.

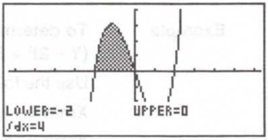
■ Calculating the Integral Value for a Given Range

Use the following procedure to obtain integration values for a given range.

1. Draw the graph.
2. Press SHIFT F5(G-SLV) F6(▷) F3(∫dx). When there are multiple graphs, this causes the selection cursor (■) to appear at the lowest numbered graph.
3. Use ▲ ▼ to move the cursor (■) to the graph you want, and then press EXE to select it.
4. Use ◀ ▶ to move the lower limit pointer to the location you want, and then press EXE.
5. Use ▶ to move the upper limit pointer to the location you want.
6. Press EXE to calculate the integral value.

Example **Graph the function shown below, and then determine the integral value at (–2, 0).**

Y1 = $x(x + 2)(x - 2)$



```
LOWER=-2        UPPER=0
∫dx=4
```

- You can also specify the lower limit and upper limit by inputting them on the 10-key pad.
- When setting the range, make sure that the lower limit is less than the upper limit.
- Integral values can be calculated for rectangular coordinate graphs only.

■ Conic Section Graph Analysis

You can determine approximations of the following analytical results using conic section graphs.

1. From the Main Menu, enter the **CONICS** mode.
2. Select the function type.
   F1(RECT).... {rectangular coordinate}
   F2(POL).... {polar coordinate}
   F3(PARM).... {parametric}
3. Use ▲ and ▼ to select the conic section you want to analyze.
4. Input the conic section constants.
5. Draw the Graph.

After graphing a conic section, press SHIFT F5(G-SLV) to display the following graph analysis menus.

• Parabolic Graph Analysis

- {**FOCS**}/{**VTX**}/{**LEN**}/{**e**} ... {focus}/{vertex}/{length of latus rectum}/{eccentricity}

- {**DIR**}/{**SYM**} ... {directrix}/{axis of symmetry}
- {**X-IN**}/{**Y-IN**} ... {x-intercept}/{y-intercept}

• Circular Graph Analysis

- {**CNTR**}/{**RADS**} ... {center}/{radius}
- {**X-IN**}/{**Y-IN**} ... {x-intercept}/{y-intercept}

• Elliptical Graph Analysis

- {**FOCS**}/{**VTX**}/{**CNTR**}/{**e**} ... {focus}/{vertex}/{center}/{eccentricity}
- {**X-IN**}/{**Y-IN**} ... {x-intercept}/{y-intercept}

• Hyperbolic Graph Analysis

- {**FOCS**}/{**VTX**}/{**CNTR**}/{**e**} ... {focus}/{vertex}/{center}/{eccentricity}
- {**ASYM**} ... {asymptote}
- {**X-IN**}/{**Y-IN**} ... {x-intercept}/{y-intercept}

• To calculate the focus and length of latus rectum [G-SLV]-[FOCS]/[LEN]

Example **To determine the focus and length of latus rectum for the parabola X = $(Y-2)^2 + 3$**

Use the following V-Window settings.

Xmin = –1, Xmax = 10, Xscale = 1

Ymin = –5, Ymax = 5, Yscale = 1

MENU CONICS

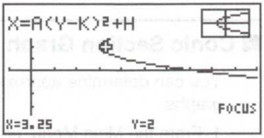
EXE

1 EXE 2 EXE 3 EXE F6(DRAW)

SHIFT F5(G-SLV)

F1(FOCS)

(Calculates the focus.)

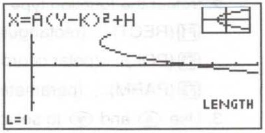


X=3.25 Y=2

SHIFT F5(G-SLV)

F5(LEN)

(Calculates the length of latus rectum.)



L=1

- When calculating two foci for an ellipse or hyperbolic graph, press ▶ to calculate the second focus. Pressing ◀ returns to the first focus.
- When calculating two vertexes for a hyperbolic graph, press ▶ to calculate the second vertex. Pressing ◀ returns to the first vertex.
- Pressing ▶ when calculating the vertices of an ellipse will calculate the next value. Pressing ◀ will scroll back through previous values. An ellipse has four vertices.

• To calculate the center [G-SLV]-[CNTR]

Example **To determine the center for the circle**

$(X + 2)^2 + (Y + 1)^2 = 2^2$

MENU CONICS

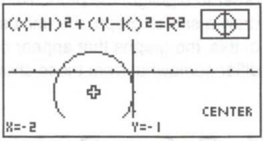
▼ ▼ ▼ ▼ EXE

(-) 2 EXE (-) 1 EXE 2 EXE F6(DRAW)

SHIFT F5(G-SLV)

F1(CNTR)

(Calculates the center.)



```
(X-H)²+(Y-K)²=R²

                    CENTER
X=-2       Y=-1
```

Chapter 6 Statistical Graphs and Calculations

Important!

This chapter contains a number of graph screen shots. In each case, new data values were input in order to highlight the particular characteristics of the graph being drawn. Note that when you try to draw a similar graph, the unit uses data values that you have input using the List function. Because of this, the graphs that appear on the screen when you perform a graphing operation will probably differ somewhat from those shown in this manual.

1. Before Performing Statistical Calculations

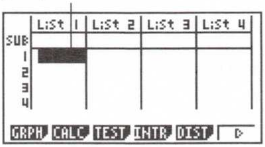
Entering the **STAT** mode from the Main Menu displays the List Editor screen.

You can use the List Editor screen to input statistical data and perform statistical calculations.

Once you input data, you can use it to produce a graph and check for tendencies. You can also use a variety of different regression calculations to analyze the data.

- For information about using the statistical data lists, see "Chapter 3 List Function".

Use ▲, ▼, ◀ and ▶ to move the highlighting around the lists.



■ Changing Graph Parameters

Use the following procedures to specify the graph draw/non-draw status, the graph type, and other general settings for each of the graphs in the graph menu (GPH1, GPH2, GPH3).

While the statistical data list is on the display, press F1(GRPH) to display the graph menu, which contains the following items.

- {**GPH1**}/{**GPH2**}/{**GPH3**} ... graph {1}/{2}/{3} drawing[*1]
- {**SEL**} ... {simultaneous graph (GPH1, GPH2, GPH3) selection}
  You can specify the multiple graphs.
- {**SET**} ... {graph settings (graph type, list assignments)}

[*1] The initial default graph type setting for all the graphs (Graph 1 through Graph 3) is scatter diagram, but you can change to one of a number of other graph types.

---

1. General graph settings [GRPH]-[SET]

This section describes how to use the general graph settings screen to make the following settings for each graph (GPH1, GPH2, GPH3).

- **Graph Type**

The initial default graph type setting for all the graphs is scatter graph. You can select one of a variety of other statistical graph types for each graph.

- **List**

The initial default statistical data is List 1 for single-variable data, and List 1 and List 2 for paired-variable data. You can specify which statistical data list you want to use for x-data and y-data.

- **Frequency**

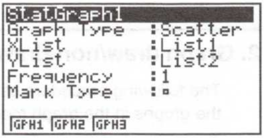
Normally, each data item or data pair in the statistical data list is represented on a graph as a point. When you are working with a large number of data items however, this can cause problems because of the number of plot points on the graph. When this happens, you can specify a frequency list that contains values indicating the number of instances (the frequency) of the data items in the corresponding cells of the lists you are using for x-data and y-data. Once you do this, only one point is plotted for the multiple data items, which makes the graph easier to read.

- **Mark Type**

This setting lets you specify the shape of the plot points on the graph.

• To display the general graph settings screen [GRPH]-[SET]

Pressing F1(GRPH)F6(SET) displays the general graph settings screen.



```
StatGraph1
Graph Type   :Scatter
XList        :List1
YList        :List2
Frequency    :1
Mark Type    :□
GPH1 GPH2 GPH3
```

- **StatGraph (statistical graph specification)**
  - {**GPH1**}/{**GPH2**}/{**GPH3**} ... graph {1}/{2}/{3}
- **Graph Type (graph type specification)**
  - {**Scat**}/{***xy***}/{**NPP**}/{**Pie**} ... {scatter diagram}/{xy line graph}/{normal probability plot}/{pie graph}
  - {**Hist**}/{**Box**}/{**Bar**}/{**N·Dis**}/{**Brkn**} ... {histogram}/{med-box graph}/{bar graph}/{normal distribution curve}/{broken line graph}
  - {**X**}/{**Med**}/{**X^2**}/{**X^3**}/{**X^4**} ... {linear regression graph}/{Med-Med graph}/{quadratic regression graph}/{cubic regression graph}/{quartic regression graph}
  - {**Log**}/{**Exp**}/{**Pwr**}/{**Sin**}/{**Lgst**} ... {logarithmic regression graph}/{exponential regression graph}/{power regression graph}/{sinusoidal regression graph}/{logistic regression graph}
- **XList (x-axis data list)/YList (y-axis data list)**
  - {**List**} ... {List 1 to 26}
- **Frequency (number of times a value occurs)**
  - {**1**} ... {1-to-1 plot}
  - {**List**} ... {List 1 to 26}
- **Mark Type (plot mark type)**
  - {□}/{×}/{•} ... scatter diagram plot points

When "Pie" (pie graph) is selected as the Graph Type:

- **Data (Specifies the list to be used as graph data.)**
  - {**LIST**} ... {List 1 to List 26}

- **Display (pie graph value display setting)**
  - {**%**}/{**Data**} ... For each data element {display as percentage}/{display as value}
- **% Sto Mem (Specifies storage of percentage values to a list.)**
  - {**None**}/{**List**} ... For percentage values: {Do not store to list}/{Specify List 1 to 26 and store}

When "Box" (med-box graph) is selected as the Graph Type:

- **Outliers (outliers specification)**
  - {**On**}/{**Off**} ... {display}/{do not display} Med-Box outliers

When "Bar" (bar graph) is selected as the Graph Type:

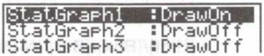
- **Data1 (first stick data list)**
  - {**LIST**} ... {List 1 to 26}
- **Data2 (second stick data list)/Data3 (third stick data list)**
  - {**None**}/{**LIST**} ... {none}/{List 1 to 26}
- **Stick Style (stick style specification)**
  - {**Leng**}/{**HZtl**} ... {length}/{horizontal}

2. Graph draw/non-draw status [GRPH]-[SEL]

The following procedure can be used to specify the draw (On)/non-draw (Off) status of each of the graphs in the graph menu.

• To specify the draw/non-draw status of a graph

1. Pressing F1(GRPH) F4(SEL) displays the graph On/Off screen.



```
StatGraph1  :DrawOn
StatGraph2  :DrawOff
StatGraph3  :DrawOff
```

   - Note that the StatGraph1 setting is for Graph 1 (GPH1 of the graph menu), StatGraph2 is for Graph 2, and StatGraph3 is for Graph 3.

2. Use the cursor keys to move the highlighting to the graph whose status you want to change, and press the applicable function key to change the status.
   - {**On**}/{**Off**} ... {On (draw)}/{Off (non-draw)}
   - {**DRAW**} ... {draws all On graphs}

3. To return to the graph menu, press EXIT.

- V-Window parameters are normally set automatically for statistical graphing. If you want to set V-Window parameters manually, you must change the Stat Wind item to "Manual".

  While the statistical data list is on the display, perform the following procedure.

  SHIFT MENU (SET UP) F2 (Man)

  EXIT (Returns to previous menu.)

  Note that V-Window parameters are set automatically for the following types of graphs regardless of whether or not the Stat Wind item is set to "Manual".

  Pie, 1-Sample Z Test, 2-Sample Z Test, 1-Prop Z Test, 2-Prop Z Test, 1-Sample t Test, 2-Sample t Test, χ^2 GOF Test, χ^2 2-way Test, 2-Sample F Test (x-axis only disregarded).

- The default setting automatically uses List 1 data as x-axis (horizontal) values and List 2 data as y-axis (vertical) values. Each set of x/y data is a point on the scatter diagram.

2. Calculating and Graphing Single-Variable Statistical Data

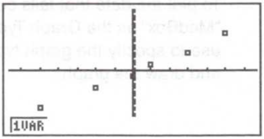
Single-variable data is data with only a single variable. If you are calculating the average height of the members of a class for example, there is only one variable (height).

Single-variable statistics include distribution and sum. The following types of graphs are available for single-variable statistics.

You can also use the procedures under "Changing Graph Parameters" on page 6-1 to make the settings you want before drawing each graph.

■ Normal Probability Plot

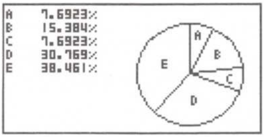
This plot compares the data accumulated ratio with a normal distribution accumulated ratio. XList specifies the list where data is input, and Mark Type is used to select from among the marks {□ / × / • } you want to plot.



Press AC, EXIT or SHIFT EXIT (QUIT) to return to the statistical data list.

■ Pie Graph

You can draw a pie graph based on the data in a specific list. The maximum number of graph data items (list lines) is 20. The graph is labeled A, B, C, and so on, corresponding to lines 1, 2, 3, and so on of the list used for the graph data.

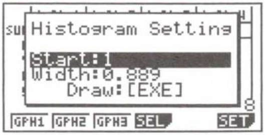


A 7.6923%
B 15.384%
C 7.6923%
D 30.769%
E 38.461%

When "%" is selected for the "Display" setting on the general graph settings screen (page 6-3), a value showing the percentage is displayed for each of the alphabetic label letters.

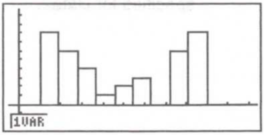
■ Histogram

XList specifies the list where the data is input, while Freq specifies the list where the data frequency is input. 1 is specified for Freq when frequency is not specified.



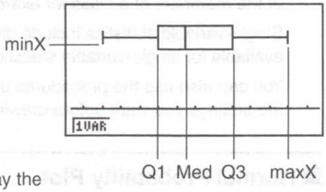
Histogram Setting
Start:1
Width:0.889
Draw:[EXE]

⇒
EXE (DRAW)



The display screen appears as shown above before the graph is drawn. At this point, you can change the Start and Width values.

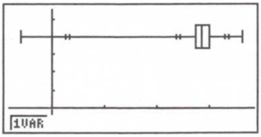
■ Med-box Graph



This type of graph lets you see how a large number of data items are grouped within specific ranges. A box encloses all the data in an area from the first quartile (Q1) to the third quartile (Q3), with a line drawn at the median (Med). Lines (called whiskers) extend from either end of the box up to the minimum (minX) and maximum (maxX) of the data.

From the statistical data list, press F1(GRPH) to display the graph menu, press F6(SET), and then change the graph type of the graph you want to use (GPH1, GPH2, GPH3) to med-box graph.

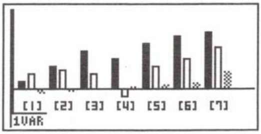
To plot the data that falls outside the box, first specify "MedBox" as the Graph Type. Then, on the same screen you use to specify the graph type, turn the Outliers item "On", and draw the graph.



- Changing the "Q1Q3 Type" setting on the Setup screen can cause the Q1 and Q3 positions to change, even when a Med-box graph is drawn based on a single list.

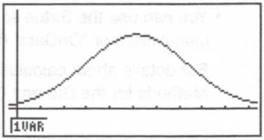
■ Bar Graph

You can specify up to three lists for drawing a bar graph. The graph is labeled [1], [2], [3], and so on, corresponding to lines 1, 2, 3, and so on of the list used for the graph data.



- Any of the following causes an error and cancels bar graph drawing.
  - A Condition ERROR occurs when drawing of multiple graphs is specified using the graph On/Off screen (page 6-3), and bar graph is specified for one of the graphs and a different graph type is specified for another graph.
  - A Dimension ERROR occurs when you draw a graph with two or three lists specified and the specified lists have a different number of list elements.
  - A Condition ERROR occurs when lists are assigned for Data1 and Data3, while "None" is specified for Data2.

Normal Distribution Curve



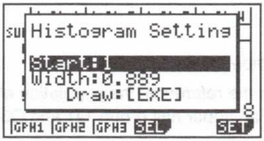
The normal distribution curve is graphed using the normal distribution function.

XList specifies the list where the data is input, while Freq specifies the list where the data frequency is input. 1 is specified for Freq when frequency is not specified.

Broken Line Graph

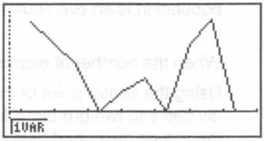
Lines connect center points of a histogram bar.

XList specifies the list where the data is input, while Freq specifies the list where the data frequency is input. 1 is specified for Freq when frequency is not specified.



```
Histogram Setting
Start:1
Width:0.889
   Draw:[EXE]
```

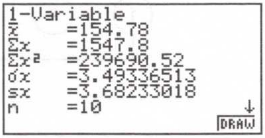
⇒ EXE(DRAW)



The display screen appears as shown above before the graph is drawn. At this point, you can change the Start and Width values.

Displaying the Calculation Results of a Drawn Single-Variable Graph

Single-variable statistics can be expressed as both graphs and parameter values. When these graphs are displayed, the single-variable calculation results appear as shown to the right when you press F1(1VAR).



```
1-Variable
x̄    =154.78
Σx   =1547.8
Σx²  =239690.52
σx   =3.49336513
sx   =3.68233018
n    =10
```

- Use ⊙ to scroll the list so you can view the items that run off the bottom of the screen.

The following describes the meaning of each of the parameters.

$\bar{x}$	mean
Σx	sum
Σx^2	sum of squares
σ_x	population standard deviation
s_x	sample standard deviation
n	number of data items
minX	minimum

Q1	first quartile
Med	median
Q3	third quartile
maxX	maximum
Mod	mode
Mod:n	number of data mode items
Mod:F	data mode frequency

- Press F6(DRAW) to return to the original single-variable statistical graph.
- When Mod has multiple solutions, they are all displayed.
- You can use the Setup screen's "Q1Q3 Type" setting to select either "Std" (standard calculation) or "OnData" (French calculation) for the Q1 and Q3 calculation mode.

  For details about calculation methods while "Std" or "OnData" is selected, see "Calculation Methods for the Std and OnData Settings" below.

Calculation Methods for the Std and OnData Settings

Q1 and Q3 can be calculated in accordance with the Setup screen's "Q1Q3 Type" setting as described below.

• Std

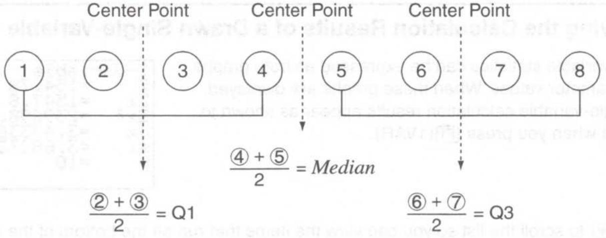
With this calculation method, processing depends on whether the number of elements n in the population is an even number or odd number.

When the number of elements n is an even number:

Using the center point of the total population as the reference, the population elements are divided into two groups: a lower half group and an upper half group. Q1 and Q3 then become the values described below.

Q1 = {median of the group of $\frac{n}{2}$ items from the bottom of the population}

Q3 = {median of the group of $\frac{n}{2}$ items from the top of the population}



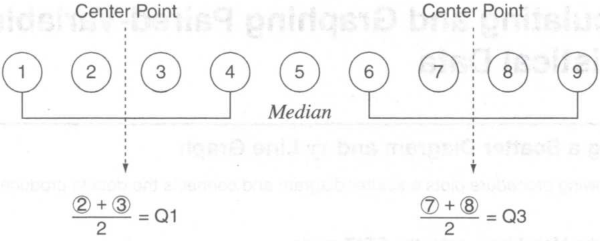
When the number of elements n is an odd number:

Using the median of the total population as the reference, the population elements are divided into two groups: a lower half group (values less than the median) and an upper half group (values greater than the median). The median value is excluded. Q1 and Q3 then become the values described below.

Q1 = {median of the group of $\frac{n-1}{2}$ items from the bottom of the population}

Q3 = {median of the group of $\frac{n-1}{2}$ items from the top of the population}

- When n = 1, Q1 = Q3 = population center point.


Center Point
Center Point
1
2
3
4
5
6
7
8
9
Median
(② + ③)/2 = Q1
(⑦ + ⑧)/2 = Q3

- **OnData**

The Q1 and Q3 values for this calculation method are described below.

Q1 = {value of element whose cumulative frequency ratio is greater than 1/4 and nearest to 1/4}

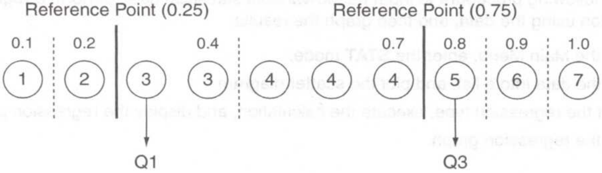
Q3 = {value of element whose cumulative frequency ratio is greater than 3/4 and nearest to 3/4}

The following shows an actual example of the above.

(Number of Elements: 10)

Data Value	Frequency	Cumulative Frequency	Cumulative Frequency Ratio
1	1	1	1/10 = 0.1
2	1	2	2/10 = 0.2
3	**2**	**4**	**4/10 = 0.4**
4	3	7	7/10 = 0.7
5	**1**	**8**	**8/10 = 0.8**
6	1	9	9/10 = 0.9
7	1	10	10/10 = 1.0

- 3 is the value of whose cumulative frequency ratio is greater than 1/4 and nearest to 1/4, so Q1 = 3.
- 5 is the value of whose cumulative frequency ratio is greater than 3/4 and nearest to 3/4, so Q3 = 5.


Reference Point (0.25)
Reference Point (0.75)
0.1
0.2
0.4
0.7
0.8
0.9
1.0
1
2
3
3
4
4
4
5
6
7
Q1
Q3

3. Calculating and Graphing Paired-Variable Statistical Data

■ Drawing a Scatter Diagram and *xy* Line Graph

The following procedure plots a scatter diagram and connects the dots to produce an *xy* line graph.

1. From the Main Menu, enter the **STAT** mode.
2. Input the data into a list.
3. Specify Scat (scatter diagram) or *xy* (*xy* line graph) as the graph type, and then execute the graph operation.

Press AC, EXIT or SHIFT EXIT(QUIT) to return to the statistical data list.

Example **Input the two sets of data shown below. Next, plot the data on a scatter diagram and connect the dots to produce an *xy* line graph.**

0.5, 1.2, 2.4, 4.0, 5.2 (*x*List)

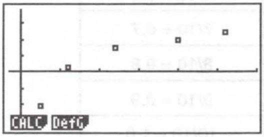
–2.1, 0.3, 1.5, 2.0, 2.4 (*y*List)

① MENU STAT

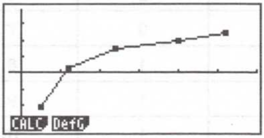
② 0 . 5 EXE 1 . 2 EXE 2 . 4 EXE 4 EXE 5 . 2 EXE ▶
(−) 2 . 1 EXE 0 . 3 EXE 1 . 5 EXE 2 EXE 2 . 4 EXE

③ (Scatter diagram) F1(GRPH) F6(SET) ▼ F1(Scat) EXIT F1(GPH1)

③ (*xy* line graph) F1(GRPH) F6(SET) ▼ F2(*xy*) EXIT F1(GPH1)



(Scatter diagram)



(*xy* line graph)

■ Drawing a Regression Graph

Use the following procedure to input paired-variable statistical data, perform a regression calculation using the data, and then graph the results.

1. From the Main Menu, enter the **STAT** mode.
2. Input the data into a list, and plot the scatter diagram.
3. Select the regression type, execute the calculation, and display the regression parameters.
4. Draw the regression graph.

Example **Input the two sets of data shown below and plot the data on a scatter diagram. Next, perform logarithmic regression on the data to display the regression parameters, and then draw the corresponding regression graph.**

0.5, 1.2, 2.4, 4.0, 5.2 (*x*List)

–2.1, 0.3, 1.5, 2.0, 2.4 (*y*List)

① MENU STAT

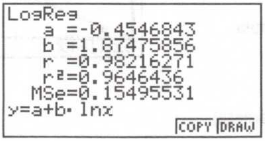
② 0 · 5 EXE 1 · 2 EXE 2 · 4 EXE 4 EXE 5 · 2 EXE ▶

(–) 2 · 1 EXE 0 · 3 EXE 1 · 5 EXE 2 EXE 2 · 4 EXE

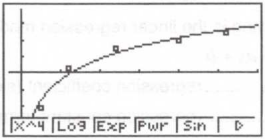
F1(GRPH) F6(SET) ▼ F1(Scat) EXIT F1(GPH1)

③ F1(CALC) F6(▷) F2(Log)

④ F6(DRAW)



```
LogReg
   a =-0.4546843
   b =1.87475856
   r =0.98216271
   r²=0.9646436
  MSe=0.15495531
y=a+b·lnx
```



- You can perform trace on a regression graph. You cannot perform trace scroll.
- Input a positive integer for frequency data. Other types of values (decimals, etc.) cause an error.

■ Selecting the Regression Type

After you graph paired-variable statistical data, you can use the function menu at the bottom of the display to select from a variety of different types of regression.

- {***ax+b***}/{***a+bx***}/{**Med**}/{**X^2**}/{**X^3**}/{**X^4**}/{**Log**}/{***ae^bx***}/{***ab^x***}/{**Pwr**}/{**Sin**}/{**Lgst**} ...
  {linear regression (*ax*+*b* form)}/{linear regression (*a*+*bx* form)}/{Med-Med}/{quadratic regression}/{cubic regression}/{quartic regression}/{logarithmic regression}/{exponential regression (ae^{bx} form)}/{exponential regression (ab^{x} form)}/{power regression}/{sinusoidal regression}/{logistic regression} calculation and graphing
- {**2VAR**}... {paired-variable statistical results}

■ Displaying Regression Calculation Results

Whenever you perform a regression calculation, the regression formula parameter (such as a and b in the linear regression $y = ax + b$) calculation results appear on the display. You can use these to obtain statistical calculation results.

Regression parameters are calculated as soon as you press a function key to select a regression type, while a graph is on the display.

The following parameters are used by linear regression, logarithmic regression, exponential regression, and power regression.

r .... correlation coefficient

r^2 .... coefficient of determination

MSe .... mean square error

Graphing Statistical Calculation Results

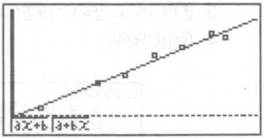
While the parameter calculation result is on the display, you can graph the displayed regression formula by pressing F6(DRAW).

Linear Regression Graph

Linear regression uses the method of least squares to plot a straight line that passes close to as many data points as possible, and returns values for the slope and y-intercept (y-coordinate when $x = 0$) of the line.

The graphic representation of this relationship is a linear regression graph.

F1(CALC)F2(X)
F1($ax+b$) or F2($a+bx$)
F6(DRAW)



The following is the linear regression model formula.

$y = ax + b$

a .... regression coefficient (slope)

b .... regression constant term (y-intercept)

$y = a + bx$

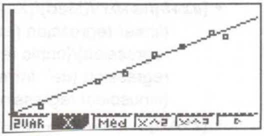
a .... regression constant term (y-intercept)

b .... regression coefficient (slope)

Med-Med Graph

When it is suspected that there are a number of extreme values, a Med-Med graph can be used in place of the least squares method. This is similar to linear regression, but it minimizes the effects of extreme values.

F1(CALC)F3(Med)
F6(DRAW)



The following is the Med-Med graph model formula.

$y = ax + b$

a .... Med-Med graph slope

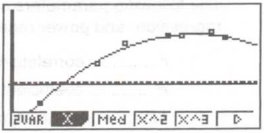
b .... Med-Med graph y-intercept

Quadratic/Cubic/Quartic Regression Graph

A quadratic/cubic/quartic regression graph represents connection of the data points of a scatter diagram. It uses the method of least squares to draw a curve that passes close to as many data points as possible. The formula that represents this is quadratic/cubic/quartic regression.

Ex. Quadratic regression

F1(CALC)F4(X^2)
F6(DRAW)



Quadratic regression

Model formula....... $y = ax^2 + bx + c$

a.......... regression second coefficient
b.......... regression first coefficient
c.......... regression constant term (y-intercept)

Cubic regression

Model formula....... $y = ax^3 + bx^2 + cx + d$

a.......... regression third coefficient
b.......... regression second coefficient
c.......... regression first coefficient
d.......... regression constant term (y-intercept)

Quartic regression

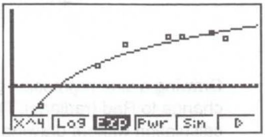
Model formula....... $y = ax^4 + bx^3 + cx^2 + dx + e$

a.......... regression fourth coefficient
b.......... regression third coefficient
c.......... regression second coefficient
d.......... regression first coefficient
e.......... regression constant term (y-intercept)

■ Logarithmic Regression Graph

Logarithmic regression expresses y as a logarithmic function of x. The standard logarithmic regression formula is $y = a + b \times \ln x$, so if we say that $X = \ln x$, the formula corresponds to linear regression formula $y = a + bX$.

F1(CALC)F6(▷)F2(Log)
F6(DRAW)



The following is the logarithmic regression model formula.

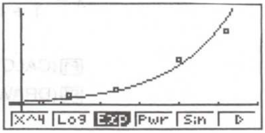
$y = a + b \cdot \ln x$

a............. regression constant term
b............. regression coefficient

■ Exponential Regression Graph

Exponential regression expresses y as a proportion of the exponential function of x. The standard exponential regression formula is $y = a \times e^{bx}$, so if we take the logarithms of both sides we get $\ln y = \ln a + bx$. Next, if we say $Y = \ln y$, and $A = \ln a$, the formula corresponds to linear regression formula $Y = A + bx$.

F1(CALC)F6(▷)F3(Exp)
F1(ae^bx) or F2(ab^x)
F6(DRAW)



The following is the exponential regression model formula.

$y = a \cdot e^{bx}$

a............. regression coefficient
b............. regression constant term

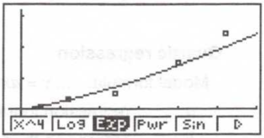
$y = a \cdot b^x$

a............. regression constant term
b............. regression coefficient

■ Power Regression Graph

Power regression expresses y as a proportion of the power of x. The standard power regression formula is $y = a \times x^b$, so if we take the logarithm of both sides we get $\ln y = \ln a + b \times \ln x$. Next, if we say $X = \ln x$, $Y = \ln y$, and $A = \ln a$, the formula corresponds to linear regression formula $Y = A + bX$.

F1(CALC) F6(▷) F4(Pwr)
F6(DRAW)



The following is the power regression model formula.

$y = a \cdot x^b$

a .... regression coefficient

b .... regression power

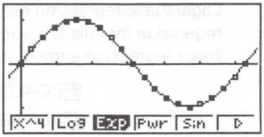
■ Sinusoidal Regression Graph

Sinusoidal regression is best applied for cyclical data.

The following is the sinusoidal regression model formula.

$$y = a \cdot \sin(bx + c) + d$$

F1(CALC) F6(▷) F5(Sin)
F6(DRAW)



Drawing a sine regression graph causes the angle unit setting of the calculator to automatically change to Rad (radians). The angle unit does not change when you perform a sine regression calculation without drawing a graph.

- Certain types of data may take a long time to calculate. This does not indicate malfunction.

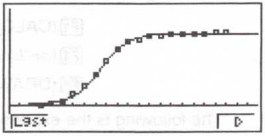
■ Logistic Regression Graph

Logistic regression is best applied for time-based phenomena in which there is a continual increase until a saturation point is reached.

The following is the logistic regression model formula.

$$y = \frac{c}{1 + ae^{-bx}}$$

F1(CALC) F6(▷) F6(▷) F1(Lgst)
F6(DRAW)



- Certain types of data may take a long time to calculate. This does not indicate malfunction.

■ Residual Calculation

Actual plot points (y-coordinates) and regression model distance can be calculated during regression calculations.

While the statistical data list is on the display, recall the Setup screen to specify a LIST ("List 1" through "List 26") for "Resid List". Calculated residual data is stored in the specified list.

The vertical distance from the plots to the regression model will be stored in the list.

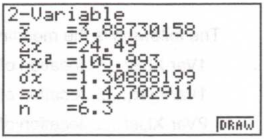
Plots that are higher than the regression model are positive, while those that are lower are negative.

Residual calculation can be performed and saved for all regression models.

Any data already existing in the selected list is cleared. The residual of each plot is stored in the same precedence as the data used as the model.

■ Displaying the Calculation Results of a Drawn Paired-Variable Graph

Paired-variable statistics can be expressed as both graphs and parameter values. When these graphs are displayed, the paired-variable calculation results appear as shown below when you press F1(CALC)F1(2VAR).



```
2-Variable
x̄   =3.88730158
Σx  =24.49
Σx² =105.993
σx  =1.30888199
sx  =1.42702911
n   =6.3
```

- Use ▼ to scroll the list so you can view the items that run off the bottom of the screen.

$\bar{x}$	mean of data stored in *x*List	Σy^2	sum of squares of data stored in *y*List
Σx	sum of data stored in *x*List	σ_y	population standard deviation of data stored in *y*List
Σx^2	sum of squares of data stored in *x*List	s_y	sample standard deviation of data stored in *y*List
σ_x	population standard deviation of data stored in *x*List	Σxy	sum of the product of data stored in *x*List and *y*List
s_x	sample standard deviation of data stored in *x*List	minX	minimum of data stored in *x*List
n	number of data	maxX	maximum of data stored in *x*List
$\bar{y}$	mean of data stored in *y*List	minY	minimum of data stored in *y*List
Σy	sum of data stored in *y*List	maxY	maximum of data stored in *y*List

■ Copying a Regression Graph Formula to the GRAPH Mode

You can copy regression formula calculation results to the **GRAPH** mode Graph relation list, and store and compare.

1. While a regression calculation result is on the display (see "Displaying Regression Calculation Results" on page 6-10), press F5(COPY).
    - This will display the **GRAPH** mode Graph relation list.*1
2. Use ▲ and ▼ to highlight the area to which you want to copy the regression formula of the displayed result.
3. Press EXE to save the copied graph formula and return to the previous regression calculation result display.

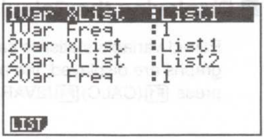
*1 You cannot edit regression formulas for graph formulas in the **GRAPH** mode.

4. Performing Statistical Calculations

All of the statistical calculations up to this point were performed after displaying a graph. The following procedures can be used to perform statistical calculations alone.

• To specify statistical calculation data lists

You have to input the statistical data for the calculation you want to perform and specify where it is located before you start a calculation. Display the statistical data and then press F2(CALC)F6(SET).



```
1Var XList  :List1
1Var Freq   :1
2Var XList  :List1
2Var YList  :List2
2Var Freq   :1


LIST
```

The following is the meaning for each item.

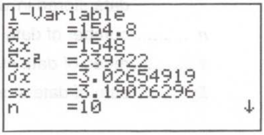
- 1Var XList.......location of single-variable statistic x values (XList)
- 1Var Freq........location of single-variable frequency values (Frequency)
- 2Var XList.......location of paired-variable statistic x values (XList)
- 2Var YList ....location of paired-variable statistic y values (YList)
- 2Var Freq........location of paired-variable frequency values (Frequency)

- Calculations in this section are performed based on the above specifications.

■ Single-Variable Statistical Calculations

In the previous example under "Displaying the Calculation Results of a Drawn Single-Variable Graph", statistical calculation results were displayed after the graph was drawn. These were numeric expressions of the characteristics of variables used in the graphic display.

These values can also be directly obtained by displaying the statistical data list and pressing F2(CALC)F1(1VAR).



```
1-Variable
x̄    =154.8
Σx   =1548
Σx²  =239722
σx   =3.02654919
sx   =3.19026296
n    =10         ↓
```

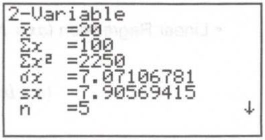
After this, pressing ▲ or ▼ scrolls the statistical calculation result display so you can view variable characteristics.

For details on the meanings of these statistical values, see "Displaying the Calculation Results of a Drawn Single-Variable Graph" (page 6-6).

■ Paired-Variable Statistical Calculations

In the previous example under "Displaying the Calculation Results of a Drawn Paired-Variable Graph", statistical calculation results were displayed after the graph was drawn. These were numeric expressions of the characteristics of variables used in the graphic display.

These values can also be directly obtained by displaying the statistical data list and pressing F2(CALC)F2(2VAR).



```
2-Variable
x̄   =20
Σx  =100
Σx² =2250
σx  =7.07106781
sx  =7.90569415
n   =5              ↓
```

After this, pressing ⊙ or ⊙ scrolls the statistical calculation result display so you can view variable characteristics.

For details on the meanings of these statistical values, see "Displaying the Calculation Results of a Drawn Paired-Variable Graph" (page 6-14).

■ Regression Calculation

In the explanations from "Linear Regression Graph" to "Logistic Regression Graph", regression calculation results were displayed after the graph was drawn. Here, each coefficient value of the regression line or regression curve is expressed as a number.

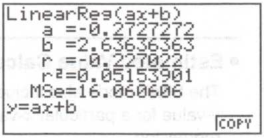
You can directly determine the same expression from the data input screen.

Pressing F2(CALC)F3(REG) displays a function menu, which contains the following items.

- {*ax+b*}/{*a+bx*}/{**Med**}/{**X^2**}/{**X^3**}/{**X^4**}/{**Log**}/{*ae^bx*}/{*ab^x*}/{**Pwr**}/{**Sin**}/{**Lgst**} ...
  {linear regression (*ax+b* form)}/{linear regression (*a+bx* form)}/{Med-Med}/{quadratic regression}/{cubic regression}/{quartic regression}/{logarithmic regression}/{exponential regression (ae^{bx} form)}/{exponential regression (ab^x form)}/{power regression}/{sinusoidal regression}/{logistic regression} parameters

Example **To display single-variable regression parameters**

F2(CALC)F3(REG)F1(X)F1(*ax+b*)

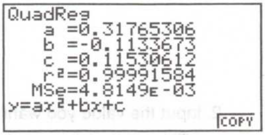


```
LinearReg(ax+b)
    a =-0.2727272
    b =2.63636363
    r =-0.227022
    r²=0.05153901
   MSe=16.060606
y=ax+b
                    COPY
```

The meanings of the parameters that appear on this screen are the same as those for "Linear Regression Graph" to "Logistic Regression Graph".

• Calculation of the Coefficient of Determination (r^2) and MSe

You can use the **STAT** mode to calculate the coefficient of determination (r^2) for quadratic regression, cubic regression, and quartic regression. The following types of MSe calculations are also available for each type of regression.



```
QuadReg
    a =0.31765306
    b =-0.1133673
    c =0.11530612
    r²=0.99991584
   MSe=4.8149E-03
y=ax²+bx+c
                    COPY
```

- Linear Regression ($ax+b$)............ $MSe = \dfrac{1}{n-2}\displaystyle\sum_{i=1}^{n}(y_i-(ax_i+b))^2$

  ($a+bx$)............ $MSe = \dfrac{1}{n-2}\displaystyle\sum_{i=1}^{n}(y_i-(a+bx_i))^2$

- Quadratic Regression.................... $MSe = \dfrac{1}{n-3}\displaystyle\sum_{i=1}^{n}(y_i-(ax_i^2+bx_i+c))^2$

- Cubic Regression .... $MSe = \dfrac{1}{n-4}\displaystyle\sum_{i=1}^{n}(y_i-(ax_i^3+bx_i^2+cx_i+d))^2$

- Quartic Regression .... $MSe = \dfrac{1}{n-5}\displaystyle\sum_{i=1}^{n}(y_i-(ax_i^4+bx_i^3+cx_i^2+dx_i+e))^2$

- Logarithmic Regression................ $MSe = \dfrac{1}{n-2}\displaystyle\sum_{i=1}^{n}(y_i-(a+b\ln x_i))^2$

- Exponential Repression ($a\cdot e^{bx}$)....... $MSe = \dfrac{1}{n-2}\displaystyle\sum_{i=1}^{n}(\ln y_i-(\ln a+bx_i))^2$

  ($a\cdot b^x$)....... $MSe = \dfrac{1}{n-2}\displaystyle\sum_{i=1}^{n}(\ln y_i-(\ln a+(\ln b)\cdot x_i))^2$

- Power Regression .... $MSe = \dfrac{1}{n-2}\displaystyle\sum_{i=1}^{n}(\ln y_i-(\ln a+b\ln x_i))^2$

- Sin Regression .... $MSe = \dfrac{1}{n-2}\displaystyle\sum_{i=1}^{n}(y_i-(a\sin(bx_i+c)+d))^2$

- Logistic Regression .... $MSe = \dfrac{1}{n-2}\displaystyle\sum_{i=1}^{n}\left(y_i-\dfrac{C}{1+ae^{-bx_i}}\right)^2$

• Estimated Value Calculation for Regression Graphs

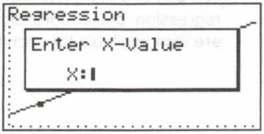
The **STAT** mode also includes a Y-CAL function that uses regression to calculate the estimated y-value for a particular x-value after graphing a paired-variable statistical regression.

The following is the general procedure for using the Y-CAL function.

1. After drawing a regression graph, press SHIFT F5(G-SLV) F1(Y-CAL) to enter the graph selection mode, and then press EXE.

   If there are multiple graphs on the display, use ▲ and ▼ to select the graph you want, and then press EXE.

   - This causes an x-value input dialog box to appear.



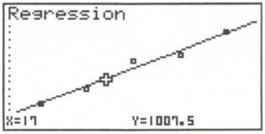
Regression

Enter X-Value

X:

2. Input the value you want for x and then press EXE.

   - This causes the coordinates for x and y to appear at the bottom of the display, and moves the pointer to the corresponding point on the graph.



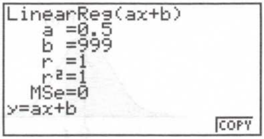
Regression

X=17 Y=1007.5

3. Pressing X,θ,T or a number key at this time causes the x-value input dialog box to reappear so you can perform another estimated value calculation if you want.
   - The pointer does not appear if the calculated coordinates are not within the display range.
   - The coordinates do not appear if "Off" is specified for the "Coord" item of the Setup screen.
   - The Y-CAL function can also be used with a graph drawn by using DefG feature.

• Regression Formula Copy Function from a Regression Calculation Result Screen

In addition to the normal regression formula copy function that lets you copy the regression calculation result screen after drawing a statistical graph (such as Scatter Plot), the **STAT** mode also has a function that lets you copy the regression formula obtained as the result of a regression calculation. To copy a resulting regression formula, press F6(COPY).



```
LinearReg(ax+b)
   a =0.5
   b =999
   r =1
   r²=1
  MSe=0
y=ax+b
```

■ Estimated Value Calculation ($\hat{x}$, $\hat{y}$)

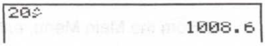
After drawing a regression graph with the **STAT** mode, you can use the **RUN • MAT** mode to calculate estimated values for the regression graph's x and y parameters.

Example **To perform a linear regression using the nearby data and estimate the values of $\hat{y}$ and $\hat{x}$ when xi = 20 and yi = 1000**

xi	10	15	20	25	30
yi	1003	1005	1010	1011	1014

1. From the Main Menu, enter the **STAT** mode.
2. Input data into the list and draw the linear regression graph.
3. From the Main Menu, enter the **RUN • MAT** mode.
4. Press the keys as follows.

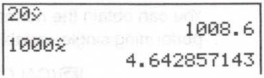
2 0 (value of xi)
OPTN F5(STAT) F2($\hat{y}$) EXE



```
20ŷ
                1008.6
```

The estimated value $\hat{y}$ is displayed for xi = 20.

1 0 0 0 (value of yi)
F1($\hat{x}$) EXE



```
20ŷ
                1008.6
1000x̂
           4.642857143
```

The estimated value $\hat{x}$ is displayed for yi = 1000.

- You cannot obtain estimated values for a Med-Med, quadratic regression, cubic regression, quartic regression, sinusoidal regression, or logistic regression graph.

Normal Probability Distribution Calculation

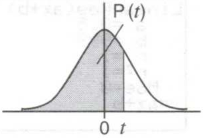
You can calculate normal probability distributions for single-variable statistics with the **RUN • MAT** mode.

Press OPTN F6(▷) F3(PROB) F6(▷) to display a function menu, which contains the following items.

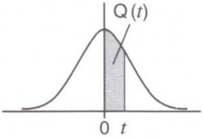
- {**P(**}/{**Q(**}/{**R(**} ... obtains normal probability {P(*t*)}/{Q(*t*)}/{R(*t*)} value
- {***t*(**} ... {obtains normalized variate *t*(*x*) value}

- Normal probability P(*t*), Q(*t*), and R(*t*), and normalized variate *t*(*x*) are calculated using the following formulas.

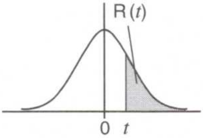
Standard Normal Distribution



$$\frac{1}{\sqrt{2\pi}}\int_{-\infty}^{t} e^{-\frac{u^2}{2}}du$$



$$\frac{1}{\sqrt{2\pi}}\int_{0}^{t} e^{-\frac{u^2}{2}}du$$



$$\frac{1}{\sqrt{2\pi}}\int_{t}^{+\infty} e^{-\frac{u^2}{2}}du$$

$$t(x) = \frac{x-\bar{x}}{\sigma x}$$

Example **The following table shows the results of measurements of the height of 20 college students. Determine what percentage of the students fall in the range 160.5 cm to 175.5 cm. Also, in what percentile does the 175.5 cm tall student fall?**

Class no.	Height (cm)	Frequency
1	158.5	1
2	160.5	1
3	163.3	2
4	167.5	2
5	170.2	3
6	173.3	4
7	175.5	2
8	178.6	2
9	180.4	2
10	186.7	1

1. From the Main Menu, enter the **STAT** mode.
2. Input the height data into List 1 and the frequency data into List 2.
3. Perform the single-variable statistical calculations.

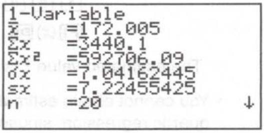
   You can obtain the normalized variate immediately after performing single-variable statistical calculations only.

   F2(CALC) F6(SET)

   F1(LIST) 1 EXE

   ▼ F2(LIST) 2 EXE SHIFT EXIT(QUIT)

   F2(CALC) F1(1VAR)



```
1-Variable
x̄     =172.005
Σx    =3440.1
Σx²   =592706.09
σx    =7.04162445
sx    =7.22455425
n     =20              ↓
```

4. Press [MENU], select the **RUN • MAT** mode, press [OPTN] [F6](▷) [F3](PROB) to recall the probability calculation (PROB) menu.

[F3](PROB) [F6](▷) [F4](*t*() [1] [6] [0] [•] [5] [)] [EXE]

(Normalized variate *t* for 160.5 cm) Result: −1.633855948 (≒ −1.634)

[F4](*t*() [1] [7] [5] [•] [5] [)] [EXE]

(Normalized variate *t* for 175.5 cm) Result: 0.4963343361 (≒ 0.496)

[F1](P() [0] [•] [4] [9] [6] [)] [−]
[F1](P() [(−)] [1] [•] [6] [3] [4] [)] [EXE]

(Percentage of total) Result: 0.638921 (63.9% of total)

[F3](R() [0] [•] [4] [9] [6] [)] [EXE]

(Percentile) Result: 0.30995 (31.0 percentile)

■ Drawing a Normal Probability Distribution Graph

You can draw a normal probability distribution graph using manual graphing with the **RUN • MAT** mode.

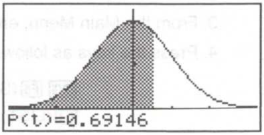
1. From the Main Menu, enter the **RUN • MAT** mode.
2. Input the commands to draw a rectangular coordinate graph.
3. Input the probability value.

Example **To draw a normal probability P (0.5) graph.**

① [MENU] RUN • MAT

② [SHIFT] [F4](SKTCH) [F1](Cls) [EXE]
[F5](GRPH) [F1](Y=)

③ [OPTN] [F6](▷) [F3](PROB) [F6](▷) [F1](P() [0] [•] [5] [)] [EXE]



P(t)=0.69146

■ Calculations Using the Distribution Function

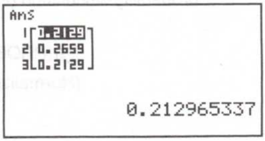
You can use special functions in the **RUN • MAT** mode or **PRGM** mode to perform calculations that are the same as the **STAT** mode distribution function calculation (page 6-38).

Example **To calculate normal probability distribution in the RUN • MAT mode for the data {1, 2, 3}, when the population standard deviation is $\sigma = 1.5$ and the population mean is $\mu = 2$.**

1. From the Main Menu, enter the **RUN • MAT** mode.

2. Press the keys as follows.

OPTN F5(STAT) F3(DIST) F1(NORM)
F1(NPd) SHIFT ×({) 1 , 2 , 3
SHIFT ÷(}) , 1 . 5 , 2) EXE



```
Ans
 1[0.2129]
 2|0.2659|
 3[0.2129]
              0.212965337
```

- For details about what you can do with the distribution function and its syntax, see "Performing Distribution Calculations in a Program" (page 8-29).

■ Determining Standard Deviation and Variance from List Data

You can use functions to determine standard deviation and variance for specified list data. This calculation is performed in the **RUN • MAT** mode. You can perform calculations using data you saved to a list (List 1 to List 26) with the **STAT** mode List Editor or list data you input directly on the **RUN • MAT** mode screen.

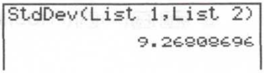
Syntax StdDev(List *n* [,List *m*])
Variance(List *n* [,List *m*])
List *n*........Sample data
List *m*.......Frequency data

Example **To store the x-data below in List 1, the frequency values in List 2, and determine the standard deviation and variance**

x	60	70	80	90
Frequency	3	5	4	1

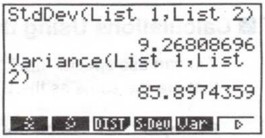
1. From the Main Menu, enter the **STAT** mode.
2. Use the List Editor to store the above data.
3. From the Main Menu, enter the **RUN • MAT** mode.
4. Press the keys as follows.

OPTN F5(STAT) F4(S • Dev) EXIT
F1(LIST) F1(List) 1 , F1(List) 2) EXE



```
StdDev(List 1,List 2)
               9.26808696
```

EXIT F5(STAT) F5(Var) EXIT
F1(LIST) F1(List) 1 , F1(List) 2) EXE



```
StdDev(List 1,List 2)
               9.26808696
Variance(List 1,List
2)
               85.8974359
```

■ Calculations Using the TEST Command

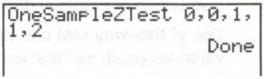
You can use special functions in the **RUN • MAT** mode or **PRGM** mode to perform calculations that are the same as the **STAT** mode *Z* Test, *t* Test, and other test calculations (page 6-22).

Example **To determine the *z* score and *p*-value when a one-sample *Z* test is performed under the conditions below:**
test condition (μ condition) $\neq \mu_0$*, assumed population mean $\mu_0 = 0$, population standard deviation $\sigma = 1$, sample mean $\bar{x} = 1$, number of samples $n = 2$

* "μ condition $\neq \mu_0$" can be specified by entering 0 as the initial argument of the one-sample *Z* test command "OneSampleZTest".

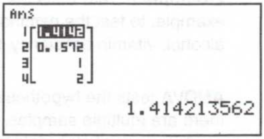
1. From the Main Menu, enter the **RUN • MAT** mode.
2. Perform the following key operation.

OPTN F5(STAT) F6(▷) F1(TEST) F1(Z)
F1(1-S) 0 , 0 , 1 , 1 , 2
EXE



```
OneSampleZTest 0,0,1,
1,2
                  Done
```

EXIT EXIT EXIT
F1(LIST) F1(List) SHIFT (–)(Ans) EXE



```
Ans
 1[1.4142]
 2[0.1572]
 3[     1]
 4[     2]

            1.414213562
```

The following calculation results are displayed as ListAns elements 1 through 4.

1: *z* score

2: *p*-value

3: $\bar{x}$

4: *n*

- For details about the function of the supported TEST command and their syntax, see "Using the TEST Command to Execute a Command in a Program" (page 8-32).

5. Tests

The ***Z* Test** provides a variety of different standardization-based tests. They make it possible to test whether or not a sample accurately represents the population when the standard deviation of a population (such as the entire population of a country) is known from previous tests. *Z* testing is used for market research and public opinion research, that need to be performed repeatedly.

1-Sample *Z* Test tests for the unknown population mean when the population standard deviation is known.

2-Sample *Z* Test tests the equality of the means of two populations based on independent samples when both population standard deviations are known.

1-Prop *Z* Test tests for an unknown proportion of successes.

2-Prop *Z* Test tests to compare the proportion of successes from two populations.

The ***t* Test** tests the hypothesis when the population standard deviation is unknown. The hypothesis that is the opposite of the hypothesis being proven is called the *null hypothesis*, while the hypothesis being proved is called the *alternative hypothesis*. The *t* Test is normally applied to test the null hypothesis. Then a determination is made whether the null hypothesis or alternative hypothesis will be adopted.

1-Sample *t* Test tests the hypothesis for a single unknown population mean when the population standard deviation is unknown.

2-Sample *t* Test compares the population means when the population standard deviations are unknown.

LinearReg *t* Test calculates the strength of the linear association of paired data.

With the **χ^2 test**, a number of independent groups are provided and a hypothesis is tested relative to the probability of samples being included in each group.

The **χ^2 GOF test** (χ^2 one-way Test) tests whether the observed count of sample data fits a certain distribution. For example, it can be used to determine conformance with normal distribution or binomial distribution.

The **χ^2 two-way test** creates a cross-tabulation table that structures mainly two qualitative variables (such as "Yes" and "No"), and evaluates the independence of the variables.

2-Sample *F* Test tests the hypothesis for the ratio of sample variances. It could be used, for example, to test the carcinogenic effects of multiple suspected factors such as tobacco use, alcohol, vitamin deficiency, high coffee intake, inactivity, poor living habits, etc.

ANOVA tests the hypothesis that the population means of the samples are equal when there are multiple samples. It could be used, for example, to test whether or not different combinations of materials have an effect on the quality and life of a final product.

One-Way ANOVA is used when there is one independent variable and one dependent variable.

Two-Way ANOVA is used when there are two independent variables and one dependent variable.

The following pages explain various statistical calculation methods based on the principles described above. Details concerning statistical principles and terminology can be found in any standard statistics textbook.

On the initial **STAT** mode screen, press F3(TEST) to display the test menu, which contains the following items.

- F3(TEST) F1(Z) ... *Z* Tests (page 6-24)
  F2(t) ... *t* Tests (page 6-26)
  F3(CHI) ... χ^2 Test (page 6-29)
  F4(F) ... 2-Sample *F* Test (page 6-30)
  F5(ANOV) ... ANOVA (page 6-31)

After setting all the parameters, use ▼ to move the highlighting to "Execute" and then press one of the function keys shown below to perform the calculation or draw the graph.

- F1(CALC) ... Performs the calculation.
- F6(DRAW) ... Draws the graph.

- V-Window settings are automatically optimized for drawing the graph.

■ *Z* Tests

• *Z* Test Common Functions

You can use the following graph analysis functions after drawing a *Z* Test result output graph.

- F1(Z) ... Displays *z* score.

Pressing F1(Z) displays the *z* score at the bottom of the display, and displays the pointer at the corresponding location in the graph (unless the location is off the graph screen).

Two points are displayed in the case of a two-tail test. Use ◀ and ▶ to move the pointer.

- F2(P) ... Displays *p*-value.

Pressing F2(P) displays the *p*-value at the bottom of the display without displaying the pointer.

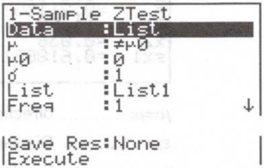
- Executing an analysis function automatically stores the *z* and *p* values in alpha variables Z and P, respectively.

• 1-Sample *Z* Test

This test is used when the population standard deviation is known to test the hypothesis. The **1-Sample *Z* Test** is applied to the normal distribution.

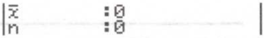
Perform the following key operations from the statistical data list.

F3(TEST)
F1(Z)
F1(1-S)



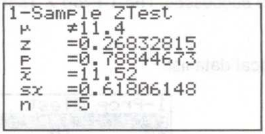
```
1-Sample ZTest
Data     :List
μ        :≠μ0
μ0       :0
σ        :1
List     :List1
Freq     :1

Save Res:None
Execute
```

The following shows the parameter data specification items that are different from list data specification.

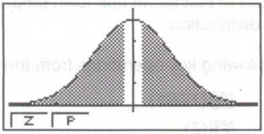


```
x̄        :0
n        :0
```

Calculation Result Output Example



```
1-Sample ZTest
μ    ≠11.4
z    =0.26832815
p    =0.78844673
x̄    =11.52
sx   =0.61806148
n    =5
```



$\mu \neq 11.4$ .... direction of test

s_x .... Displayed only for Data: List setting.

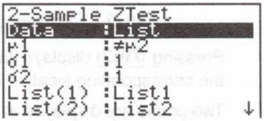
- [Save Res] does not save the μ condition in line 2.

• 2-Sample *Z* Test

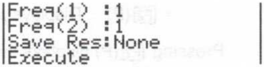
This test is used when the standard deviations for two populations are known to test the hypothesis. The **2-Sample *Z* Test** is applied to the normal distribution.

Perform the following key operations from the statistical data list.

F3(TEST)
F1(Z)
F2(2-S)

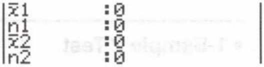


```
2-Sample ZTest
Data      :List
μ1        :≠μ2
σ1        :1
σ2        :1
List(1)   :List1
List(2)   :List2   ↓
```



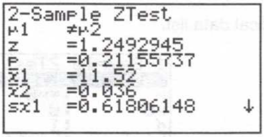
```
Freq(1)   :1
Freq(2)   :1
Save Res:None
Execute
```

The following shows the parameter data specification items that are different from list data specification.

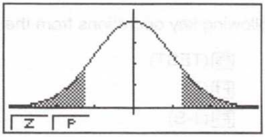


```
x̄1        :0
n1        :0
x̄2        :0
n2        :0
```

Calculation Result Output Example



```
2-Sample ZTest
μ1   ≠μ2
z    =1.2492945
p    =0.21155737
x̄1   =11.52
x̄2   =0.036
sx1  =0.61806148    ↓
```



$\mu_1 \neq \mu_2$ .... direction of test

s_{x1} .... Displayed only for Data: List setting.

s_{x2} .... Displayed only for Data: List setting.

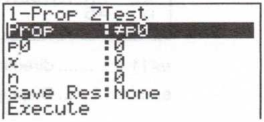
- [Save Res] does not save the μ_1 condition in line 2.

• 1-Prop *Z* Test

This test is used to test for an unknown proportion of successes. The **1-Prop *Z* Test** is applied to the normal distribution.

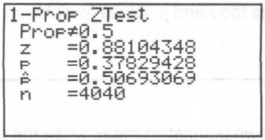
Perform the following key operations from the statistical data list.

F3(TEST)
F1(Z)
F3(1-P)

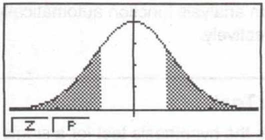


```
1-Prop ZTest
Prop      :≠p0
p0        :0
x         :0
n         :0
Save Res:None
Execute
```

Calculation Result Output Example



```
1-Prop ZTest
 Prop≠0.5
 z    =0.88104348
 p    =0.37829428
 p̂    =0.50693069
 n    =4040
```



Prop≠0.5 .... direction of test

- [Save Res] does not save the Prop condition in line 2.

• 2-Prop *Z* Test

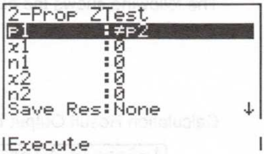
This test is used to compare the proportion of successes. The **2-Prop *Z* Test** is applied to the normal distribution.

Perform the following key operation from the statistical data list.

F3(TEST)

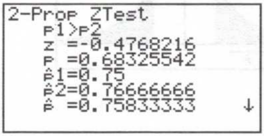
F1(Z)

F4(2-P)

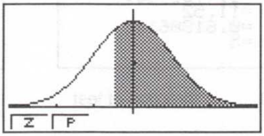


```
2-Prop ZTest
p1          :≠p2
x1          :0
n1          :0
x2          :0
n2          :0
Save Res:None       ↓

Execute
```

Calculation Result Output Example



```
2-Prop ZTest
    p1>p2
    z =-0.4768216
    p =0.68325542
    p̂1=0.75
    p̂2=0.76666666
    p̂ =0.75833333     ↓
```



$p_1 > p_2$ .... direction of test

- [Save Res] does not save the p_1 condition in line 2.

■ *t* Tests

• *t* Test Common Functions

You can use the following graph analysis functions after drawing a *t* Test result output graph.

- F1(T) ... Displays *t* score.

Pressing F1(T) displays the *t* score at the bottom of the display, and displays the pointer at the corresponding location in the graph (unless the location is off the graph screen).

Two points are displayed in the case of a two-tail test. Use ◀ and ▶ to move the pointer.

- F2(P) ... Displays *p*-value.

Pressing F2(P) displays the p-value at the bottom of the display without displaying the pointer.

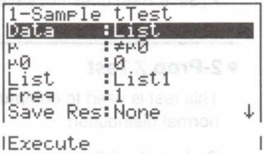
- Executing an analysis function automatically stores the t and p values in alpha variables T and P, respectively.

• 1-Sample *t* Test

This test uses the hypothesis test for a single unknown population mean when the population standard deviation is unknown. The **1-Sample *t* Test** is applied to t distribution.

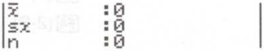
Perform the following key operations from the statistical data list.

F3(TEST)
F2(t)
F1(1-S)



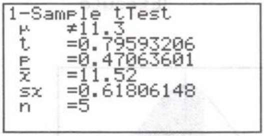
```
1-Sample tTest
Data      :List
μ         :≠μ0
μ0        :0
List      :List1
Freq      :1
Save Res:None        ↓

Execute
```

The following shows the parameter data specification items that are different from list data specification.

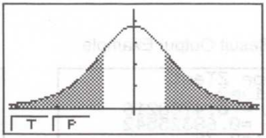


```
x̄         :0
sx        :0
n         :0
```

Calculation Result Output Example



```
1-Sample tTest
 μ    ≠11.3
 t    =0.79593206
 p    =0.47063601
 x̄    =11.52
 sx   =0.61806148
 n    =5
```



$\mu \neq 11.3$ .... direction of test

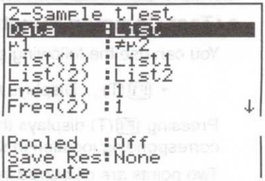
- [Save Res] does not save the μ condition in line 2.

• 2-Sample *t* Test

2-Sample *t* Test compares the population means when the population standard deviations are unknown. The **2-Sample *t* Test** is applied to t distribution.

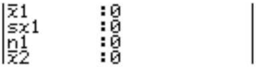
Perform the following key operations from the statistical data list.

F3(TEST)
F2(t)
F2(2-S)

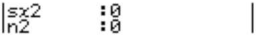


```
2-Sample tTest
Data      :List
μ1        :≠μ2
List(1)   :List1
List(2)   :List2
Freq(1)   :1
Freq(2)   :1         ↓

Pooled    :Off
Save Res:None
Execute
```

The following shows the parameter data specification items that are different from list data specification.

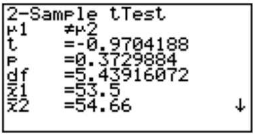


```
x̄1      :0
sx1     :0
n1      :0
x̄2      :0
```

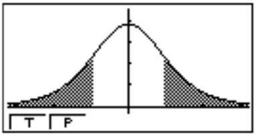


```
sx2     :0
n2      :0
```

Calculation Result Output Example



```
2-Sample tTest
μ1    ≠μ2
t     =-0.9704188
p     =0.3729884
df    =5.43916072
x̄1    =53.5
x̄2    =54.66         ↓
```



$\mu_1 \neq \mu_2$ .... direction of test

s_p .... Displayed only when Pooled: On setting.

- [Save Res] does not save the μ_1 condition in line 2.

• LinearReg *t* Test

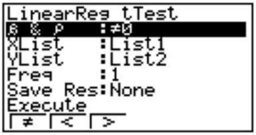
LinearReg *t* Test treats paired-variable data sets as (x, y) pairs, and uses the method of least squares to determine the most appropriate a, b coefficients of the data for the regression formula $y = a + bx$. It also determines the correlation coefficient and t score, and calculates the extent of the relationship between x and y.

Perform the following key operations from the statistical data list.

F3(TEST)

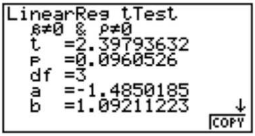
F2(t)

F3(REG)



```
LinearReg tTest
β & ρ    :≠0
XList    :List1
YList    :List2
Freq     :1
Save Res:None
Execute
```

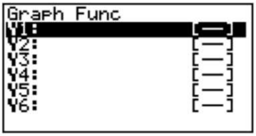
Calculation Result Output Example



```
LinearReg tTest
  β≠0 & ρ≠0
  t   =2.39793632
  p   =0.0960526
  df  =3
  a   =-1.4850185
  b   =1.09211223     ↓
```

$\beta \neq 0$ & $\rho \neq 0$ .... direction of test

Pressing F6(COPY) while a calculation result is on the display copies the regression formula to the Graph relation list.



```
Graph Func
Y1:                [—]
Y2:                [—]
Y3:                [—]
Y4:                [—]
Y5:                [—]
Y6:                [—]
```

When there is a list specified for the [Resid List] item on the Setup screen, regression formula residual data is automatically saved to the specified list after the calculation is finished.

- You cannot draw a graph for LinearReg t Test.
- [Save Res] does not save the β & ρ conditions in line 2.
- When the list specified by [Save Res] is the same list specified by the [Resid List] item on the Setup screen, only [Resid List] data is saved in the list.

■ χ^2 Test

• χ^2 Test Common Functions

You can use the following graph analysis functions after drawing a graph.

- F1(CHI) ... Displays χ^2 value.

Pressing F1(CHI) displays the χ^2 value at the bottom of the display, and displays the pointer at the corresponding location in the graph (unless the location is off the graph screen).

- F2(P) ... Displays p-value.

Pressing F2(P) displays the p-value at the bottom of the display without displaying the pointer.

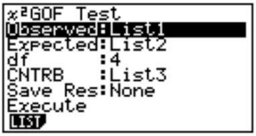
- Executing an analysis function automatically stores the χ^2 and p values in alpha variables C and P, respectively.

• χ^2 GOF Test (χ^2 one-way Test)

The χ^2 **GOF Test** (χ^2 one-way test) tests whether the frequency of sample data fits a certain distribution. For example, it can be used to determine conformance with normal distribution or binomial distribution.

Perform the following key operations from the statistical data list.

F3(TEST)
F3(CHI)
F1(GOF)



```
χ²GOF Test
Observed:List1
Expected:List2
df      :4
CNTRB   :List3
Save Res:None
Execute
```

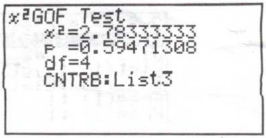
Next, specify the lists that contain the data. The following shows the meaning of the above items.

Observed ...... name of List (1 to 26) that contains observed counts (all cells positive integers)

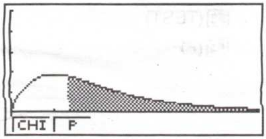
Expected....... name of List (1 to 26) that is for saving expected frequency

CNTRB .... Specifies a list (List 1 to List 26) as the storage location of the contribution of each observed count obtained as calculation results.

Calculation Result Output Examples



```
χ²GOF Test
 χ²=2.78333333
 p =0.59471308
 df=4
 CNTRB:List3
```



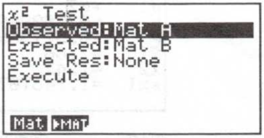
CNTRB .... list for output of contribution values

• χ^2 two-way Test

χ^2 two-way Test sets up a number of independent groups and tests hypothesis related to the proportion of the sample included in each group. The χ^2 Test is applied to dichotomous variables (variable with two possible values, such as yes/no).

Perform the following key operations from the statistical data list.

F3(TEST)
F3(CHI)
F2(2WAY)

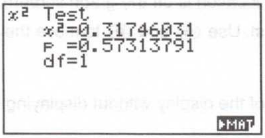


```
χ² Test
Observed:Mat A
Expected:Mat B
Save Res:None
Execute
```

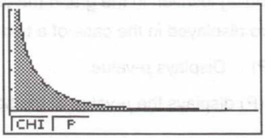
Next, specify the matrix that contains the data. The following shows the meaning of the above items.

Observed	name of matrix (A to Z) that contains observed counts (all cells positive integers)
Expected.......	name of matrix (A to Z) that is for saving expected frequency

Calculation Result Output Example



```
χ² Test
 χ²=0.31746031
 p =0.57313791
 df=1
```



- The matrix must be at least two lines by two columns. An error occurs if the matrix has only one line or one column.
- Pressing F1(Mat) while the "Observed" and "Expected" parameter settings are highlighted will display the Matrix (A to Z) setting screen.
- Pressing F2(▶MAT) while setting parameters enters the Matrix Editor, which you can use to edit and view the contents of matrices.
- Pressing F6(▶MAT) while a calculation result is displayed enters the Matrix Editor, which you can use to edit and view the contents of matrices.

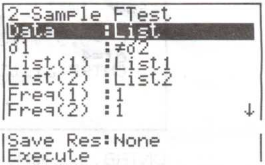
■ 2-Sample *F* Test

2-Sample *F* Test tests the hypothesis for the ratio of sample variances. The *F* Test is applied to the *F* distribution.

Perform the following key operations from the statistical data list.

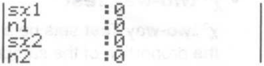
F3(TEST)

F4(F)



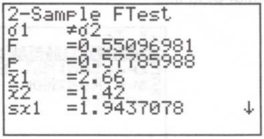
```
2-Sample FTest
Data      :List
σ1        :≠σ2
List(1)   :List1
List(2)   :List2
Freq(1)   :1
Freq(2)   :1               ↓

Save Res:None
Execute
```

The following shows the parameter data specification items that are different from list data specification.

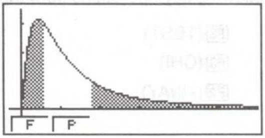


```
sx1   :0
n1    :0
sx2   :0
n2    :0
```

Calculation Result Output Example



```
2-Sample FTest
σ1    ≠σ2
F     =0.55096981
p     =0.57785988
x̄1    =2.66
x̄2    =1.42
sx1   =1.9437078         ↓
```



$\sigma_1 \neq \sigma_2$ .... direction of test

$\bar{x}_1$ .... Displayed only for Data: List setting.

$\bar{x}_2$ .... Displayed only for Data: List setting.

You can use the following graph analysis functions after drawing a graph.

- F1(F) ... Displays *F* value.

Pressing F1(F) displays the *F* value at the bottom of the display, and displays the pointer at the corresponding location in the graph (unless the location is off the graph screen).

Two points are displayed in the case of a two-tail test. Use ◀ and ▶ to move the pointer.

- F2(P) ... Displays *p*-value.

Pressing F2(P) displays the *p*-value at the bottom of the display without displaying the pointer.

- Executing an analysis function automatically stores the *F* and *p* values in alpha variables *F* and P, respectively.
- [Save Res] does not save the σ_1 condition in line 2.

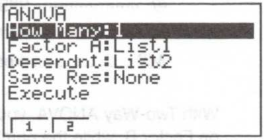
■ ANOVA

ANOVA tests the hypothesis that the population means of the samples are equal when there are multiple samples.

One-Way ANOVA is used when there is one independent variable and one dependent variable.

Two-Way ANOVA is used when there are two independent variables and one dependent variable.

Perform the following key operations from the statistical data list.


ANOVA
How Many:1
Factor A:List1
Dependnt:List2
Save Res:None
Execute

F3(TEST)
F5(ANOV)

The following is the meaning of each item in the case of list data specification.

How Many..... selects One-Way ANOVA or Two-Way ANOVA (number of levels)
Factor A........ category list (List 1 to 26)
Dependnt...... list to be used for sample data (List 1 to 26)
Save Res...... first list for storage of calculation results (None or List 1 to 22)*1
Execute......... executes a calculation or draws a graph (Two-Way ANOVA only)

*1 [Save Res] saves each vertical column of the table into its own list. The leftmost column is saved in the specified list, and each subsequent column to the right is saved in the next sequentially numbered list. Up to five lists can be used for storing columns. You can specify an first list number in the range of 1 to 22.

The following item appears in the case of Two-Way ANOVA only.

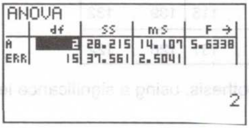
Factor B........ category list (List 1 to 26)

After setting all the parameters, use ⊙ to move the highlighting to "Execute" and then press one of the function keys shown below to perform the calculation or draw the graph.

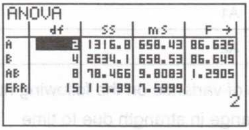
- F1(CALC).... Performs the calculation.
- F6(DRAW).... Draws the graph (Two-Way ANOVA only).

Calculation results are displayed in table form, just as they appear in science books.

Calculation Result Output Example


ANOVA

	df	SS	mS	F →
A	2	28.215	14.107	5.6338
ERR	15	37.561	2.5041	


ANOVA

	df	SS	mS	F →
A	2	1316.8	658.43	86.635
B	4	2634.1	658.53	86.649
AB	8	78.466	9.8083	1.2905
ERR	15	113.99	7.5999	

One-Way ANOVA

Line 1 (A).......... Factor A *df* value, *SS* value, *MS* value, *F* value, *p*-value
Line 2 (ERR)..... Error *df* value, *SS* value, *MS* value

Two-Way ANOVA

Line 1 (A).......... Factor A *df* value, *SS* value, *MS* value, *F* value, *p*-value
Line 2 (B).......... Factor B *df* value, *SS* value, *MS* value, *F* value, *p*-value
Line 3 (AB)........ Factor A × Factor B *df* value, *SS* value, *MS* value, *F* value, *p*-value
* Line 3 does not appear when there is only one observation in each cell.
Line 4 (ERR)..... Error *df* value, *SS* value, *MS* value
F .... *F* value

p .... *p*-value
df .... degrees of freedom
SS .... sum of squares
MS .... mean squares

With Two-Way ANOVA, you can draw Interaction Plot graphs. The number of graphs depends on Factor B, while the number of X-axis data depends on the Factor A. The Y-axis is the average value of each category.

You can use the following graph analysis function after drawing a graph.

- F1 (Trace) or SHIFT F1 (TRCE) ... Trace function

Pressing ◀ or ▶ moves the pointer on the graph in the corresponding direction. When there are multiple graphs, you can move between graphs by pressing ▲ and ▼.

- Graphing is available with Two-Way ANOVA only. V-Window settings are performed automatically, regardless of Setup screen settings.
- Using the Trace function automatically stores the number of conditions to alpha variable A and the mean value to variable M, respectively.

■ ANOVA (Two-Way)

• Description

The nearby table shows measurement results for a metal product produced by a heat treatment process based on two treatment levels: time (A) and temperature (B). The experiments were repeated twice each under identical conditions.

B (Heat Treatment Temperature) A (Time)	B1	B2
A1	113 , 116	139 , 132
A2	133 , 131	126 , 122

Perform analysis of variance on the following null hypothesis, using a significance level of 5%.

H_0 : No change in strength due to time

H_0 : No change in strength due to heat treatment temperature

H_0 : No change in strength due to interaction of time and heat treatment temperature

• Solution

Use Two-Way ANOVA to test the above hypothesis.
Input the above data as shown below.

List1={1,1,1,1,2,2,2,2}
List2={1,1,2,2,1,1,2,2}
List3={113,116,139,132,133,131,126,122}

Define List 3 (the data for each group) as Dependent. Define List 1 and List 2 (the factor numbers for each data item in List 3) as Factor A and Factor B respectively.
Executing the test produces the following results.

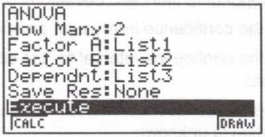
- Time differential (A) level of significance P = 0.2458019517
  The level of significance (p = 0.2458019517) is greater than the significance level (0.05), so the hypothesis is not rejected.

- Temperature differential (B) level of significance P = 0.04222398836
  The level of significance (p = 0.04222398836) is less than the significance level (0.05), so the hypothesis is rejected.

- Interaction (A × B) level of significance P = 2.78169946e-3
  The level of significance (p = 2.78169946e-3) is less than the significance level (0.05), so the hypothesis is rejected.

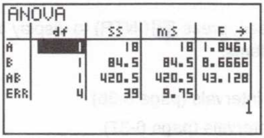
The above test indicates that the time differential is not significant, the temperature differential is significant, and interaction is highly significant.

• Input Example

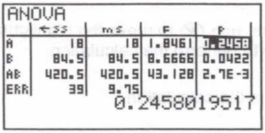


```
ANOVA
How Many:2
Factor A:List1
Factor B:List2
Dependnt:List3
Save Res:None
Execute
```

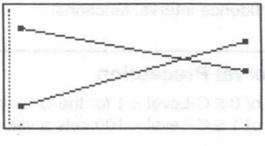
• Results



```
ANOVA
    |  df|   SS|   mS|F     →
A   |   1|   18|   18|1.8461
B   |   1| 84.5| 84.5|8.6666
AB  |   1|420.5|420.5|43.128
ERR |   4|   39| 9.75|
                            1
```



```
ANOVA
    |  ←SS|   mS|     F|     P
A   |   18|   18|1.8461|0.2458
B   | 84.5| 84.5|8.6666|0.0422
AB  |420.5|420.5|43.128|2.7E-3
ERR |   39| 9.75|
          0.2458019517
```



6. Confidence Interval

A confidence interval is a range (interval) that includes a statistical value, usually the population mean.

A confidence interval that is too broad makes it difficult to get an idea of where the population value (true value) is located. A narrow confidence interval, on the other hand, limits the population value and makes it difficult to obtain reliable results. The most commonly used confidence levels are 95% and 99%. Raising the confidence level broadens the confidence interval, while lowering the confidence level narrows the confidence level, but it also increases the chance of accidently overlooking the population value. With a 95% confidence interval, for example, the population value is not included within the resulting intervals 5% of the time.

When you plan to conduct a survey and then t test and Z test the data, you must also consider the sample size, confidence interval width, and confidence level. The confidence level changes in accordance with the application.

1-Sample Z Interval calculates the confidence interval for an unknown population mean when the population standard deviation is known.

2-Sample Z Interval calculates the confidence interval for the difference between two population means when the population standard deviations of two samples are known.

1-Prop Z Interval calculates the confidence interval for an unknown proportion of successes.

2-Prop Z Interval calculates the confidence interval for the difference between the proportion of successes in two populations.

1-Sample t Interval calculates the confidence interval for an unknown population mean when the population standard deviation is unknown.

2-Sample t Interval calculates the confidence interval for the difference between two population means when both population standard deviations are unknown.

On the initial **STAT** mode screen, press F4(INTR) to display the confidence interval menu, which contains the following items.

- F4(INTR)F1(Z) ... Z intervals (page 6-36)
  F2(t) ... t intervals (page 6-37)

After setting all the parameters, use ▽ to move the highlighting to "Execute" and then press the function key shown below to perform the calculation.

- F1(CALC) ... Performs the calculation.

- There is no graphing for confidence interval functions.

• General Confidence Interval Precaution

Inputting a value in the range of $0 \leqq$ C-Level < 1 for the C-Level setting sets a value you input. Inputting a value in the range of $1 \leqq$ C-Level < 100 sets a value equivalent to your input divided by 100.

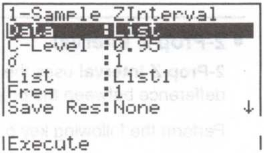
Z Interval

• 1-Sample *Z* Interval

1-Sample *Z* Interval calculates the confidence interval for an unknown population mean when the population standard deviation is known.

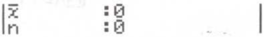
Perform the following key operations from the statistical data list.

F4(INTR)
F1(Z)
F1(1-S)



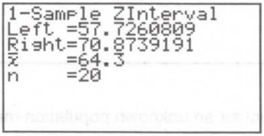
```
1-Sample ZInterval
Data     :List
C-Level  :0.95
σ        :1
List     :List1
Freq     :1
Save Res:None      ↓
Execute
```

The following shows the parameter data specification items that are different from list data specification.



```
x̄          :0
n          :0
```

Calculation Result Output Example



```
1-Sample ZInterval
Left =57.7260809
Right=70.8739191
x̄     =64.3
n     =20
```

• 2-Sample *Z* Interval

2-Sample *Z* Interval calculates the confidence interval for the difference between two population means when the population standard deviations of two samples are known.

Perform the following key operations from the statistical data list.

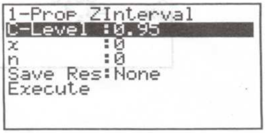
F4(INTR)
F1(Z)
F2(2-S)

• 1-Prop *Z* Interval

1-Prop *Z* Interval uses the number of data to calculate the confidence interval for an unknown proportion of successes.

Perform the following key operations from the statistical data list.

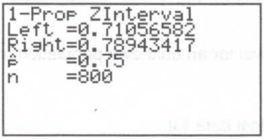
F4(INTR)
F1(Z)
F3(1-P)



```
1-Prop ZInterval
C-Level :0.95
x        :0
n        :0
Save Res:None
Execute
```

Data is specified using parameter specification.

Calculation Result Output Example



```
1-Prop ZInterval
Left =0.71056582
Right=0.78943417
p̂    =0.75
n    =800
```

• 2-Prop *Z* Interval

2-Prop *Z* Interval uses the number of data items to calculate the confidence interval for the defference between the proportion of successes in two populations.

Perform the following key operations from the statistical data list.

F4(INTR)
F1(Z)
F4(2-P)

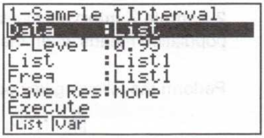
■ *t* Interval

• 1-Sample *t* Interval

1-Sample *t* Interval calculates the confidence interval for an unknown population mean when the population standard deviation is unknown.

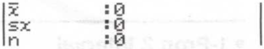
Perform the following key operations from the statistical data list.

F4(INTR)
F2(t)
F1(1-S)



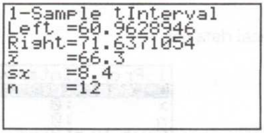
```
1-Sample tInterval
Data     :List
C-Level  :0.95
List     :List1
Freq     :List1
Save Res:None
Execute
```

The following shows the parameter data specification items that are different from list data specification.



```
x̄        :0
sx       :0
n        :0
```

Calculation Result Output Example



```
1-Sample tInterval
Left =60.9628946
Right=71.6371054
x̄    =66.3
sx   =8.4
n    =12
```

• 2-Sample *t* Interval

2-Sample *t* Interval calculates the confidence interval for the difference between two population means when both population standard deviations are unknown. The *t* interval is applied to *t* distribution.

Perform the following key operations from the statistical data list.

F4(INTR)
F2(t)
F2(2-S)

7. Distribution

There is a variety of different types of distribution, but the most well-known is "normal distribution", which is essential for performing statistical calculations. Normal distribution is a symmetrical distribution centered on the greatest occurrences of mean data (highest frequency), with the frequency decreasing as you move away from the center. Poisson distribution, geometric distribution, and various other distribution shapes are also used, depending on the data type.

Certain trends can be determined once the distribution shape is determined. You can calculate the probability of data taken from a distribution being less than a specific value.

For example, distribution can be used to calculate the yield rate when manufacturing some product. Once a value is established as the criteria, you can calculate normal probability when estimating what percent of the products meet the criteria. Conversely, a success rate target (80% for example) is set up as the hypothesis, and normal distribution is used to estimate the proportion of the products will reach this value.

Normal probability density calculates the probability density of normal distribution from a specified x value.

Normal cumulative distribution calculates the probability of normal distribution data falling between two specific values.

Inverse normal cumulative distribution calculates a value that represents the location within a normal distribution for a specific cumulative probability.

Student-*t* probability density calculates t probability density from a specified x value.

Student-*t* cumulative distribution calculates the probability of t distribution data falling between two specific values.

Inverse Student-*t* cumulative distribution calculates the lower bound value of a Student-t cumulative probability density for a specified percentage.

Like t distribution, probability density (or probability), cumulative distribution and inverse cumulative distribution can also be calculated for χ^2, F, **Binomial**, **Poisson**, **Geometric** and **Hypergeometric** distributions.

On the initial **STAT** mode screen, press F5(DIST) to display the distribution menu, which contains the following items.

- F5(DIST)F1(NORM) ... Normal distribution (page 6-39)
  - F2(t) ... Student-t distribution (page 6-41)
  - F3(CHI) ... χ^2 distribution (page 6-42)
  - F4(F) ... F distribution (page 6-43)
  - F5(BINM) ... Binomial distribution (page 6-44)
  - F6(▷)F1(POISN) ... Poisson distribution (page 6-46)
  - F6(▷)F2(GEO) ... Geometric distribution (page 6-47)
  - F6(▷)F3(H.GEO) ... Hypergeometric distribution (page 6-49)

After setting all the parameters, use ⊽ to move the highlighting to "Execute" and then press one of the function keys shown below to perform the calculation or draw the graph.

- F1(CALC) ... Performs the calculation.
- F6(DRAW) ... Draws the graph.

■ Common Distribution Functions

- V-Window settings for graph drawing are set automatically when the Setup screen's "Stat Wind" setting is "Auto". Current V-Window settings are used for graph drawing when the "Stat Wind" setting is "Manual".
- After drawing a graph, you can use the P-CAL function to calculate an estimated p-value for a particular x value. The P-CAL function can be used only after a Normal Probability Density, Student-t Probability Density, χ^2 Probability Density, or F Probability Density graph is drawn.

The following is the general procedure for using the P-CAL function.

1. After drawing a distribution graph, press SHIFT F5(G-SLV) F1(P-CAL) to display the x value input dialog box.
2. Input the value you want for x and then press EXE.
   - This causes the x and p values to appear at the bottom of the display, and moves the pointer to the corresponding point on the graph.
3. Pressing X,θ,T or a number key at this time causes the x value input dialog box to reappear so you can perform another estimated value calculation if you want.
4. After you are finished, press EXIT to clear the coordinate values and the pointer from the display.

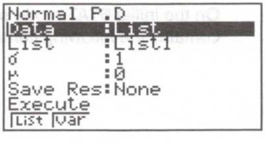
- Executing an analysis function automatically stores the x and p values in alpha variables X and P, respectively.

■ Normal Distribution

• Normal Probability Density

F5(DIST)F1(NORM)F1(NPd)

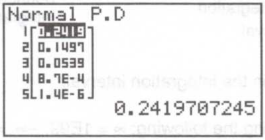
Normal Probability Density calculates the probability density (p) for a specified single x-value or a list. When a list is specified, calculation results for each list element are displayed in list form.



```
Normal P.D
Data    :List
List    :List1
σ       :1
μ       :0
Save Res:None
Execute
```

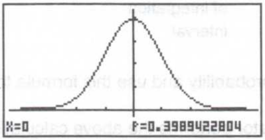
- Normal probability density is applied to standard normal distribution.
- Specifying $\sigma = 1$ and $\mu = 0$ specifies standard normal distribution.

Calculation Result Output Examples



```
Normal P.D
 1[0.2419]
 2|0.1497|
 3|0.0539|
 4|8.7E-4|
 5[1.4E-6]
          0.2419707245
```

When a list is specified



```
X=0           P=0.3989422804
```

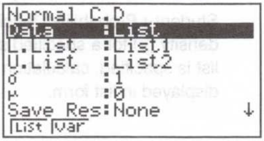
Graph when an x-value is specified

- Graphing is supported only when a variable is specified and a single x-value is entered as data.

• Normal Cumulative Distribution

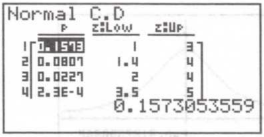
F5(DIST) F1(NORM) F2(NCd)

Normal Cumulative Distribution calculates the normal cumulative probability of a normal distribution between a lower bound and an upper bound.



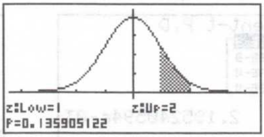
```
Normal C.D
Data      :List
L.List    :List1
U.List    :List2
σ         :1
μ         :0
Save Res:None        ↓
```

Calculation Result Output Examples



```
Normal C.D
     p      z:Low    z:Up
 1[0.1573      1        3]
 2|0.0807    1.4        4|
 3|0.0227      2        4|
 4|2.3E-4    3.5        5|
          0.1573053559
```

When a list is specified



```
z:Low=1      z:Up=2
P=0.135905122
```

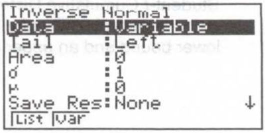
Graph when an x-value is specified

- Graphing is supported only when a variable is specified and a single x-value is entered as data.

• Inverse Normal Cumulative Distribution

F5(DIST) F1(NORM) F3(InvN)

Inverse Normal Cumulative Distribution calculates the boundary value(s) of a normal cumulative distribution probability for specified values.



```
Inverse Normal
Data      :Variable
Tail      :Left
Area      :0
σ         :1
μ         :0
Save Res:None        ↓
```

Area: probability value
(0 ≦ Area ≦ 1)

Inverse cumulative normal distribution calculates a value that represents the location within a normal distribution for a specific cumulative probability.

$$\int_{-\infty}^{Upper} f(x)dx = p$$

Tail: Left
upper boundary
of integration
interval

$$\int_{Lower}^{+\infty} f(x)dx = p$$

Tail: Right
lower boundary
of integration
interval

$$\int_{Lower}^{Upper} f(x)dx = p$$

Tail: Central
upper and lower
boundaries of
integration interval

Specify the probability and use this formula to obtain the integration interval.

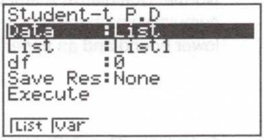
- This calculator performs the above calculation using the following: ∞ = 1E99, –∞ = –1E99
- There is no graphing for Inverse Normal Cumulative Distribution.

■ Student-*t* Distribution

• Student-*t* Probability Density

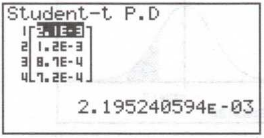
F5(DIST) F2(t) F1(tPd)

Student-*t* Probability Density calculates the probability density (p) for a specified single x-value or a list. When a list is specified, calculation results for each list element are displayed in list form.



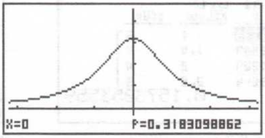
```
Student-t P.D
Data      :List
List      :List1
df        :0
Save Res:None
Execute
```

Calculation Result Output Examples



```
Student-t P.D
 1[2.1E-3]
 2|1.2E-3|
 3|8.7E-4|
 4[7.2E-4]
        2.195240594E-03
```

When a list is specified



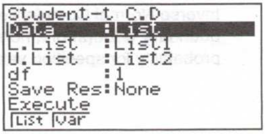
Graph when variable (x) is specified

- Graphing is supported only when a variable is specified and a single x-value is entered as data.

• Student-*t* Cumulative Distribution

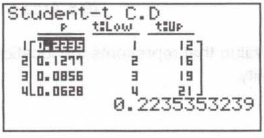
F5(DIST) F2(t) F2(tCd)

Student-*t* Cumulative Distribution calculates the Student-*t* cumulative probability of a Student-*t* distribution between a lower bound and an upper bound.



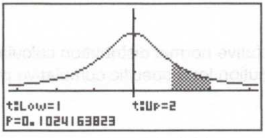
```
Student-t C.D
Data      :List
L.List    :List1
U.List    :List2
df        :1
Save Res:None
Execute
```

Calculation Result Output Examples



```
Student-t C.D
      p      t:Low   t:Up
 1[0.2235      1      12]
 2|0.1277      2      16|
 3|0.0856      3      19|
 4[0.0628      4      21]
            0.2235353239
```

When a list is specified



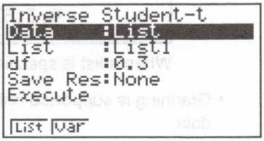
Graph when variable (x) is specified

- Graphing is supported only when a variable is specified and a single x-value is entered as data.

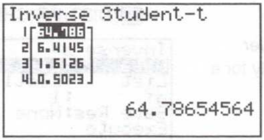
• Inverse Student-*t* Cumulative Distribution

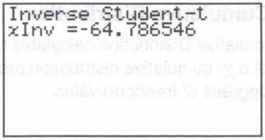
F5(DIST)F2(t)F3(InvN)

Inverse Student-*t* Cumulative Distribution calculates the lower bound value of a Student-*t* cumulative distribution for a specified *df* (degrees of freedom) value.


```
Inverse Student-t
Data      :List
List      :List1
df        :0.3
Save Res:None
Execute
```

Calculation Result Output Examples


```
Inverse Student-t
 1[64.786]
 2|6.4145|
 3|1.6126|
 4[0.5023]

              64.78654564
```
When a list is specified


```
Inverse Student-t
xInv =-64.786546
```
When variable (x) is specified

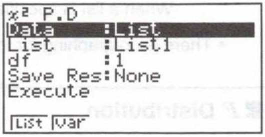
- There is no graphing for Inverse Student-*t* Cumulative Distribution.

■ χ^2 Distribution

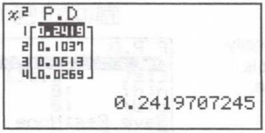
• χ^2 Probability Density

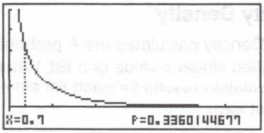
F5(DIST)F3(CHI)F1(CPd)

χ^2 Probability Density calculates the χ^2 probability density (p) for a specified single x-value or a list. When a list is specified, calculation results for each list element are displayed in list form.


```
χ² P.D
Data      :List
List      :List1
df        :1
Save Res:None
Execute
```

Calculation Result Output Examples


```
χ² P.D
 1[0.2419]
 2|0.1037|
 3|0.0513|
 4[0.0269]

            0.2419707245
```
When a list is specified



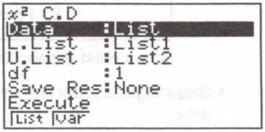
Graph when variable (x) is specified

- Graphing is supported only when a variable is specified and a single x-value is entered as data.

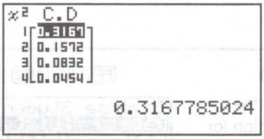
• χ^2 Cumulative Distribution

F5(DIST)F3(CHI)F2(CCd)

χ^2 Cumulative Distribution calculates the cumulative probability of a χ^2 distribution between a lower bound and an upper bound.

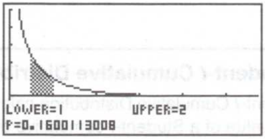

```
χ² C.D
Data      :List
L.List    :List1
U.List    :List2
df        :1
Save Res:None
Execute
```

Calculation Result Output Examples



```
χ² C.D
 1[0.3167]
 2|0.1572|
 3|0.0832|
 4[0.0454]
               0.3167785024
```

When a list is specified



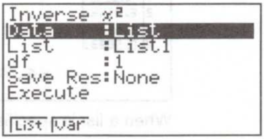
Graph when variable (x) is specified

- Graphing is supported only when a variable is specified and a single x-value is entered as data.

• Inverse χ^2 Cumulative Distribution

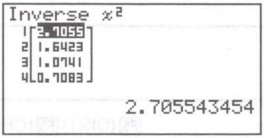
[F5](DIST)[F3](CHI)[F3](InvC)

Inverse χ^2 Cumulative Distribution calculates the lower bound value of a χ^2 cumulative distribution probability for a specified *df* (degrees of freedom) value.



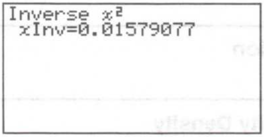
```
Inverse χ²
Data    :List
List    :List1
df      :1
Save Res:None
Execute
```

Calculation Result Output Examples



```
Inverse χ²
 1[2.7055]
 2|1.6423|
 3|1.0741|
 4[0.7083]
               2.705543454
```

When a list is specified



```
Inverse χ²
 xInv=0.01579077
```

When variable (x) is specified

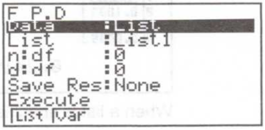
- There is no graphing for Inverse χ^2 Cumulative Distribution.

F Distribution

• *F* Probability Density

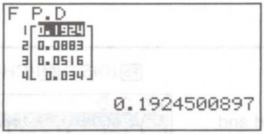
[F5](DIST)[F4](F)[F1](FPd)

F Probability Density calculates the *F* probability density (p) for a specified single x-value or a list. When a list is specified, calculation results for each list element are displayed in list form.



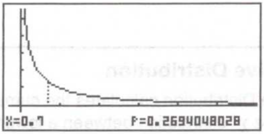
```
F P.D
Data    :List
List    :List1
n:df    :0
d:df    :0
Save Res:None
Execute
```

Calculation Result Output Examples



```
F P.D
 1[0.1924]
 2|0.0883|
 3|0.0516|
 4[ 0.034]
               0.1924500897
```

When a list is specified



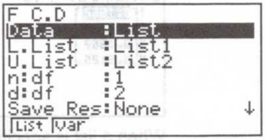
Graph when variable (x) is specified

- Graphing is supported only when a variable is specified and a single x-value is entered as data.

• *F* Cumulative Distribution

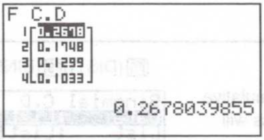
F5 (DIST) F4 (F) F2 (FCd)

F Cumulative Distribution calculates the cumulative probability of an *F* distribution between a lower bound and an upper bound.



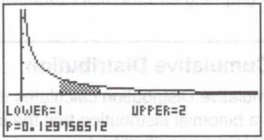
```
F C.D
Data     :List
L.List   :List1
U.List   :List2
n:df     :1
d:df     :2
Save Res:None          ↓
List Var
```

Calculation Result Output Examples



```
F C.D
 1[0.2678]
 2|0.1748|
 3|0.1299|
 4[0.1033]
              0.2678039855
```

When a list is specified



```
LOWER=1          UPPER=2
P=0.129756512
```

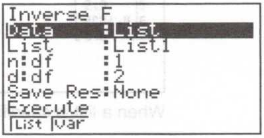
Graph when variable (x) is specified

- Graphing is supported only when a variable is specified and a single x-value is entered as data.

• Inverse *F* Cumulative Distribution

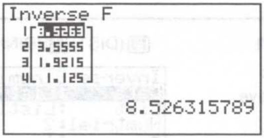
F5 (DIST) F4 (F) F3 (InvF)

Inverse *F* Cumulative Distribution calculates the lower bound value of an *F* cumulative distribution probability for specified *n*:*df* and *d*:*df* (degrees of freedom of numerator and denominator) values.



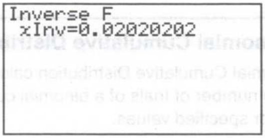
```
Inverse F
Data     :List
List     :List1
n:df     :1
d:df     :2
Save Res:None
Execute
List Var
```

Calculation Result Output Examples



```
Inverse F
 1[8.5263]
 2|3.5555|
 3|1.9215|
 4[ 1.125]
               8.526315789
```

When a list is specified



```
Inverse F
 xInv=0.02020202
```

When variable (x) is specified

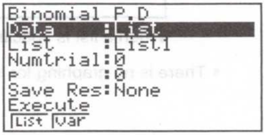
- There is no graphing for Inverse *F* Cumulative Distribution.

■ Binomial Distribution

• Binomial Probability

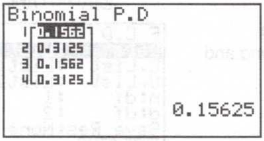
F5 (DIST) F5 (BINM) F1 (BPd)

Binomial Probability calculates a probability at a specific single x-value or each list element for the discrete binomial distribution with the specified number of trials and probability of success on each trial. When a list is specified, calculation results for each list element are displayed in list form.



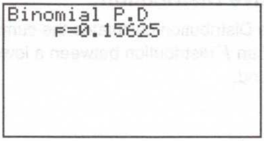
```
Binomial P.D
Data     :List
List     :List1
Numtrial:0
p        :0
Save Res:None
Execute
List Var
```

Calculation Result Output Examples



```
Binomial P.D
 1[0.1562]
 2|0.3125|
 3|0.1562|
 4[0.3125]
                  0.15625
```

When a list is specified



```
Binomial P.D
   p=0.15625
```

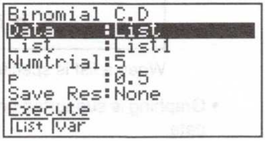
When variable (x) is specified

- There is no graphing for Binomial Probability.

• Binomial Cumulative Distribution

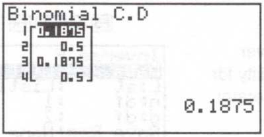
F5 (DIST) **F5** (BINM) **F2** (BCd)

Binomial Cumulative Distribution calculates the cumulative probability in a binomial distribution that the success will occur on or before a specified trial.



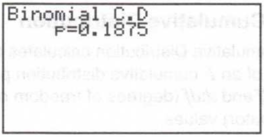
```
Binomial C.D
Data     :List
List     :List1
Numtrial:5
p        :0.5
Save Res:None
Execute
```

Calculation Result Output Examples



```
Binomial C.D
 1[0.1875]
 2|   0.5|
 3|0.1875|
 4[   0.5]
                   0.1875
```

When a list is specified



```
Binomial C.D
   p=0.1875
```

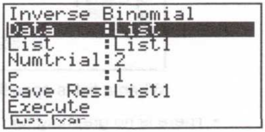
When variable (x) is specified

- There is no graphing for Binomial Cumulative Distribution.

• Inverse Binomial Cumulative Distribution

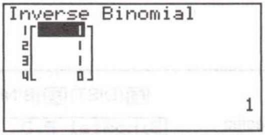
F5 (DIST) **F5** (BINM) **F3** (InvB)

Inverse Binomial Cumulative Distribution calculates the minimum number of trials of a binomial cumulative distribution for specified values.



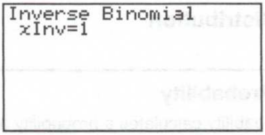
```
Inverse Binomial
Data     :List
List     :List1
Numtrial:2
p        :1
Save Res:List1
Execute
```

Calculation Result Output Examples



```
Inverse Binomial
 1[     1]
 2|     1|
 3|     1|
 4[     0]
                        1
```

When a list is specified



```
Inverse Binomial
 xInv=1
```

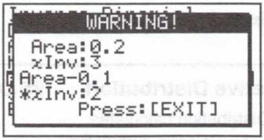
When variable (x) is specified

- There is no graphing for Inverse Binomial Cumulative Distribution.

Important!

When executing the Inverse Binomial Cumulative Distribution calculation, the calculator uses the specified Area value and the value that is one less than the Area value minimum number of significant digits (∗Area value) to calculate minimum number of trials values.

The results are assigned to system variables *x*Inv (calculation result using Area) and ∗*x*Inv (calculation result using ∗Area). The calculator always displays the *x*Inv value only. However, when the *x*Inv and ∗*x*Inv values are different, the message shown below will appear with both values.



```
WARNING!
 Area:0.2
 xInv:3
Area-0.1
*xInv:2
     Press:[EXIT]
```

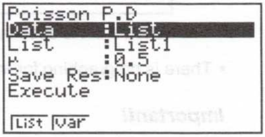
The calculation results of Inverse Binomial Cumulative Distribution are integers. Accuracy may be reduced when the first argument has 10 or more digits. Note that even a slight difference in calculation accuracy affects calculation results. If a warning message appears, check the displayed values.

■ Poisson Distribution

• Poisson Probability

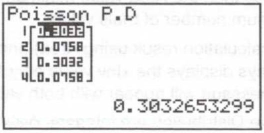
F5(DIST)F6(▷)F1(POISN)F1(PPd)

Poisson Probability calculates a probability at a specific single *x*-value or each list element for the discrete Poisson distribution with the specified mean.



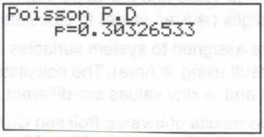
```
Poisson P.D
Data     :List
List     :List1
μ        :0.5
Save Res:None
Execute
```

Calculation Result Output Examples



```
Poisson P.D
 1 [0.3032]
 2 [0.0758]
 3 [0.3032]
 4 [0.0758]
        0.3032653299
```

When a list is specified



```
Poisson P.D
    p=0.30326533
```

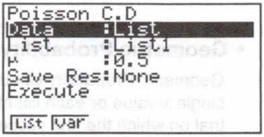
When variable (*x*) is specified

- There is no graphing for Poisson Probability.

• Poisson Cumulative Distribution

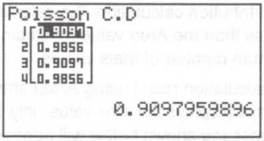
F5(DIST)F6(▷)F1(POISN)F2(PCd)

Poisson Cumulative Distribution calculates the cumulative probability in a Poisson distribution that the success will occur on or before a specified trial.



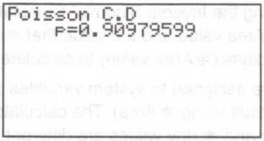
```
Poisson C.D
Data     :List
List     :List1
μ        :0.5
Save Res:None
Execute
```

Calculation Result Output Examples



```
Poisson C.D
1[0.9097]
2[0.9856]
3[0.9097]
4[0.9856]
            0.9097959896
```

When a list is specified



```
Poisson C.D
   p=0.90979599
```

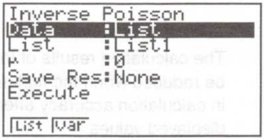
When variable (x) is specified

- There is no graphing for Poisson Cumulative Distribution.

• Inverse Poisson Cumulative Distribution

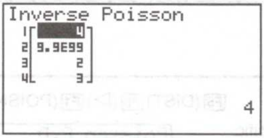
F5(DIST)F6(▷)F1(POISN)F3(InvP)

Inverse Poisson Cumulative Distribution calculates the minimum number of trials of a Poisson cumulative probability distribution for specified values.



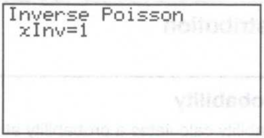
```
Inverse Poisson
Data    :List
List    :List1
μ       :0
Save Res:None
Execute
LIST VAR
```

Calculation Result Output Examples



```
Inverse Poisson
1[     4]
2[9.9E99]
3[     2]
4[     3]
                4
```

When a list is specified



```
Inverse Poisson
 xInv=1
```

When variable (x) is specified

- There is no graphing for Inverse Poisson Cumulative Distribution.

Important!

When executing the Inverse Poisson Cumulative Distribution calculation, the calculator uses the specified Area value and the value that is one less than the Area value minimum number of significant digits (∗Area value) to calculate minimum number of trials values.

The results are assigned to system variables xInv (calculation result using Area) and ∗xInv (calculation result using ∗Area). The calculator always displays the xInv value only. However, when the xInv and ∗xInv values are different, the message will appear with both values.

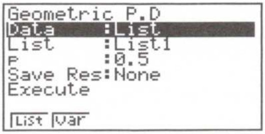
The calculation results of Inverse Poisson Cumulative Distribution are integers. Accuracy may be reduced when the first argument has 10 or more digits. Note that even a slight difference in calculation accuracy affects calculation results. If a warning message appears, check the displayed values.

■ Geometric Distribution

• Geometric Probability

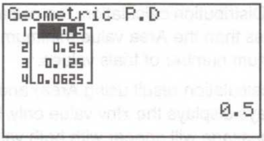
F5(DIST)F6(▷)F2(GEO)F1(GPd)

Geometric Probability calculates the probability at a specific single x-value or each list element, and the number of the trial on which the first success occurs, for the geometric distribution with a specified probability of success.



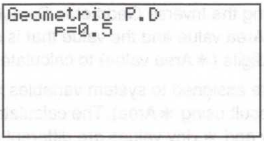
```
Geometric P.D
Data    :List
List    :List1
p       :0.5
Save Res:None
Execute
LIST VAR
```

Calculation Result Output Examples



```
Geometric P.D
1[  0.5 ]
2[ 0.25 ]
3[ 0.125]
4[0.0625]
             0.5
```

When a list is specified



```
Geometric P.D
    p=0.5
```

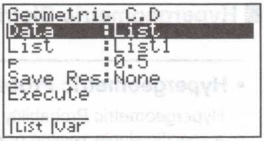
When variable (x) is specified

- There is no graphing for Geometric Probability.

• Geometric Cumulative Distribution

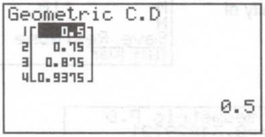
[F5](DIST)[F6](▷)[F2](GEO)[F2](GCd)

Geometric Cumulative Distribution calculates the cumulative probability in a geometric distribution that the success will occur on or before a specified trial.



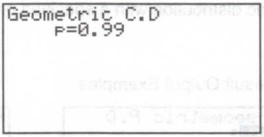
```
Geometric C.D
Data    :List
List    :List1
p       :0.5
Save Res:None
Execute
```

Calculation Result Output Examples



```
Geometric C.D
1[  0.5 ]
2[ 0.75 ]
3[ 0.875]
4[0.9375]
             0.5
```

When a list is specified



```
Geometric C.D
    p=0.99
```

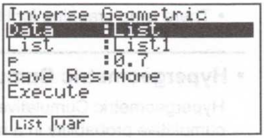
When variable (x) is specified

- There is no graphing for Geometric Cumulative Distribution.

• Inverse Geometric Cumulative Distribution

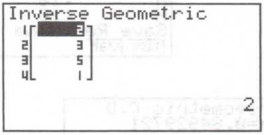
[F5](DIST)[F6](▷)[F2](GEO)[F3](InvG)

Inverse Geometric Cumulative Distribution calculates the minimum number of trials of a geometric cumulative probability distribution for specified values.



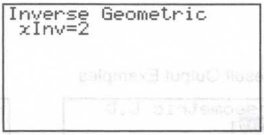
```
Inverse Geometric
Data    :List
List    :List1
p       :0.7
Save Res:None
Execute
```

Calculation Result Output Examples



```
Inverse Geometric
1[ 2 ]
2[ 3 ]
3[ 5 ]
4[ 1 ]
               2
```

When a list is specified



```
Inverse Geometric
 xInv=2
```

When variable (x) is specified

- There is no graphing for Inverse Geometric Cumulative Distribution.

Important!

When executing the Inverse Geometric Cumulative Distribution calculation, the calculator uses the specified Area value and the value that is one less than the Area value minimum number of significant digits (∗Area value) to calculate minimum number of trials values.

The results are assigned to system variables *x*Inv (calculation result using Area) and ∗*x*Inv (calculation result using ∗Area). The calculator always displays the *x*Inv value only. However, when the *x*Inv and ∗*x*Inv values are different, the message will appear with both values.

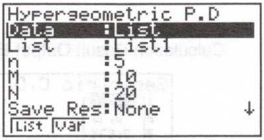
The calculation results of Inverse Geometric Cumulative Distribution are integers. Accuracy may be reduced when the first argument has 10 or more digits. Note that even a slight difference in calculation accuracy affects calculation results. If a warning message appears, check the displayed values.

Hypergeometric Distribution

• Hypergeometric Probability

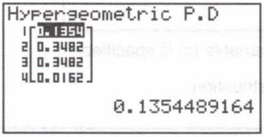
F5(DIST) F6(▷) F3(H.GEO) F1(HPd)

Hypergeometric Probability calculates the probability at a specific single *x*-value or each list element, and the number of the trial on which the first success occurs, for the hypergeometric distribution with a specified probability of success.



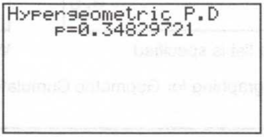
```
Hypergeometric P.D
Data    :List
List    :List1
n       :5
M       :10
N       :20
Save Res:None       ↓
```

Calculation Result Output Examples



```
Hypergeometric P.D
 1┌0.1354┐
 2│0.3482│
 3│0.3482│
 4└0.0162┘

          0.1354489164
```

When a list is specified



```
Hypergeometric P.D
    p=0.34829721
```

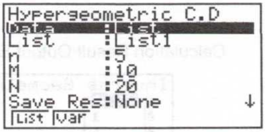
When variable (*x*) is specified

- There is no graphing for Hypergeometric Probability.

• Hypergeometric Cumulative Distribution

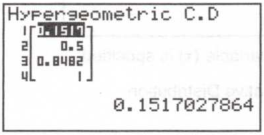
F5(DIST) F6(▷) F3(H.GEO) F2(HCd)

Hypergeometric Cumulative Distribution calculates the cumulative probability in a hypergeometric distribution that the success will occur on or before a specified trial.



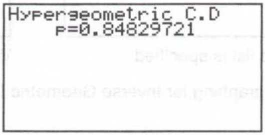
```
Hypergeometric C.D
Data    :List
List    :List1
n       :5
M       :10
N       :20
Save Res:None       ↓
```

Calculation Result Output Examples



```
Hypergeometric C.D
 1┌0.1517┐
 2│   0.5│
 3│0.8482│
 4└     1┘

          0.1517027864
```

When a list is specified



```
Hypergeometric C.D
    p=0.84829721
```

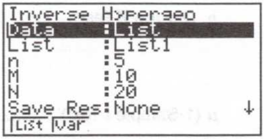
When variable (*x*) is specified

- There is no graphing for Hypergeometric Cumulative Distribution.

• Inverse Hypergeometric Cumulative Distribution

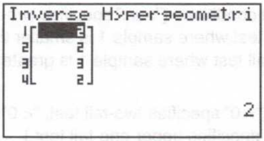
F5 (DIST) F6 (▷) F3 (H.GEO) F3 (InvH)

Inverse Hypergeometric Cumulative Distribution calculates the minimum number of trials of a hypergeometric cumulative probability distribution for specified values.



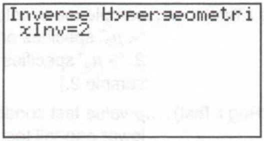
```
Inverse Hypergeo
Data    :List
List    :List1
n       :5
M       :10
N       :20
Save Res:None       ↓
```

Calculation Result Output Examples



```
Inverse Hypergeometri
 1[     2]
 2[     2]
 3[     3]
 4[     2]

                    2
```

When a list is specified



```
Inverse Hypergeometri
 xInv=2
```

When variable (x) is specified

- There is no graphing for Inverse Hypergeometric Cumulative Distribution.

Important!

When executing the Inverse Hypergeometric Cumulative Distribution calculation, the calculator uses the specified Area value and the value that is one less than the Area value minimum number of significant digits (∗Area value) to calculate minimum number of trials values.

The results are assigned to system variables *x*Inv (calculation result using Area) and ∗*x*Inv (calculation result using ∗Area). The calculator always displays the *x*Inv value only. However, when the *x*Inv and ∗*x*Inv values are different, the message will appear with both values.

The calculation results of Inverse Hypergeometric Cumulative Distribution are integers. Accuracy may be reduced when the first argument has 10 or more digits. Note that even a slight difference in calculation accuracy affects calculation results. If a warning message appears, check the displayed values.

8. Input and Output Terms of Tests, Confidence Interval, and Distribution

The following explains the input and output terms that are used by tests, confidence interval, and distribution.

■ Input Terms

Data	data type
μ (1-Sample Z Test)	population mean value test conditions ("$\neq \mu_0$" specifies two-tail test, "$< \mu_0$" specifies lower one-tail test, "$> \mu_0$" specifies upper one-tail test.)
μ_1 (2-Sample Z Test)	population mean value test conditions ("$\neq \mu_2$" specifies two-tail test, "$< \mu_2$" specifies one-tail test where sample 1 is smaller than sample 2, "$> \mu_2$" specifies one-tail test where sample 1 is greater than sample 2.)

Prop (1-Prop *Z* Test)	sample proportion test conditions ("$\neq p_0$" specifies two-tail test, "$< p_0$" specifies lower one-tail test, "$> p_0$" specifies upper one-tail test.)
p_1 (2-Prop *Z* Test)	sample proportion test conditions ("$\neq p_2$" specifies two-tail test, "$< p_2$" specifies one-tail test where sample 1 is smaller than sample 2, "$> p_2$" specifies one-tail test where sample 1 is greater than sample 2.)
μ (1-Sample *t* Test)	population mean value test conditions ("$\neq \mu_0$" specifies two-tail test, "$< \mu_0$" specifies lower one-tail test, "$> \mu_0$" specifies upper one-tail test.)
μ_1 (2-Sample *t* Test)	sample mean value test conditions ("$\neq \mu_2$" specifies two-tail test, "$< \mu_2$" specifies one-tail test where sample 1 is smaller than sample 2, "$> \mu_2$" specifies one-tail test where sample 1 is greater than sample 2.)
β & ρ (LinearReg *t* Test)	ρ-value test conditions ("$\neq 0$" specifies two-tail test, "< 0" specifies lower one-tail test, "> 0" specifies upper one-tail test.)
σ_1 (2-Sample *F* Test)	population standard deviation test conditions ("$\neq \sigma_2$" specifies two-tail test, "$< \sigma_2$" specifies one-tail test where sample 1 is smaller than sample 2, "$> \sigma_2$" specifies one-tail test where sample 1 is greater than sample 2.)
μ_0	assumed population mean
σ	population standard deviation ($\sigma > 0$)
σ_1	population standard deviation of sample 1 ($\sigma_1 > 0$)
σ_2	population standard deviation of sample 2 ($\sigma_2 > 0$)
List	list whose contents you want to use as data (List 1 to 26)
List1	list whose contents you want to use as sample 1 data (List 1 to 26)
List2	list whose contents you want to use as sample 2 data (List 1 to 26)
Freq	frequency (1 or List 1 to 26)
Freq1	frequency of sample 1 (1 or List 1 to 26)
Freq2	frequency of sample 2 (1 or List 1 to 26)
Execute	executes a calculation or draws a graph
$\bar{x}$	mean of sample
$\bar{x}_1$	mean of sample 1
$\bar{x}_2$	mean of sample 2
n	size of sample (positive integer)
n_1	size of sample 1 (positive integer)
n_2	size of sample 2 (positive integer)
p_0	expected sample proportion ($0 < p_0 < 1$)
p_1	sample proportion test conditions
x (1-Prop *Z* Test)	sample value ($x \geqq 0$ integer)
x (1-Prop *Z* Interval)	data (0 or positive integer)
x_1	data value of sample 1 ($x_1 \geqq 0$ integer)
x_2	data value of sample 2 ($x_2 \geqq 0$ integer)
s_x	sample standard deviation ($s_x > 0$)
s_{x1}	standard deviation of sample 1 ($s_{x1} > 0$)
s_{x2}	standard deviation of sample 2 ($s_{x2} > 0$)

XList	list for x-axis data (List 1 to 6)
YList	list for y-axis data (List 1 to 6)
C-Level	confidence level ($0 \leqq$ C-Level < 1)
Pooled	pooling On (in effect) or Off (not in effect)
x (Distribution)	data
σ (Distribution)	standard deviation ($\sigma > 0$)
μ (Distribution)	mean
Lower (Distribution)	lower boundary
Upper (Distribution)	upper boundary
df (Distribution)	degrees of freedom ($df > 0$)
$n{:}df$ (Distribution)	numerator degrees of freedom (positive integer)
$d{:}df$ (Distribution)	denominator degrees of freedom (positive integer)
Numtrial (Distribution)	number of trials
p (Distribution)	success probability ($0 \leqq p \leqq 1$)

Output Terms

z	z score
p	p-value
t	t score
χ^2	χ^2 value
F	F value
$\hat{p}$	estimated sample proportion
$\hat{p}_1$	estimated proportion of sample 1
$\hat{p}_2$	estimated proportion of sample 2
$\bar{x}$	mean of sample
$\bar{x}_1$	mean of sample 1
$\bar{x}_2$	mean of sample 2
s_x	sample standard deviation
s_{x1}	standard deviation of sample 1
s_{x2}	standard deviation of sample 2
s_p	pooled sample standard deviation
n	size of sample
n_1	size of sample 1
n_2	size of sample 2
df	degrees of freedom
a	constant term
b	coefficient
s_e	standard error
r	correlation coefficient
r^2	coefficient of determination
Left	confidence interval lower limit (left edge)
Right	confidence interval upper limit (right edge)

9. Statistic Formula

■ Test

Test	
1-Sample *Z* Test	$z = (\bar{x} - \mu_0)/(\sigma/\sqrt{n})$
2-Sample *Z* Test	$z = (\bar{x}_1 - \bar{x}_2)/\sqrt{(\sigma_1^2/n_1) + (\sigma_2^2/n_2)}$
1-Prop *Z* Test	$z = (x/n - p_0)/\sqrt{p_0(1 - p_0)/n}$
2-Prop *Z* Test	$z = (x_1/n_1 - x_2/n_2)/\sqrt{\hat{p}(1 - \hat{p})(1/n_1 + 1/n_2)}$
1-Sample *t* Test	$t = (\bar{x} - \mu_0)/(\mathrm{s}_x/\sqrt{n})$
2-Sample *t* Test (pooled)	$t = (\bar{x}_1 - \bar{x}_2)/\sqrt{\mathrm{s}_p^2(1/n_1 + 1/n_2)}$ $\mathrm{s}_p = \sqrt{((n_1 - 1)\mathrm{s}_{x1}^2 + (n_2 - 1)\mathrm{s}_{x2}^2)/(n_1 + n_2 - 2)}$ $df = n_1 + n_2 - 2$
2-Sample *t* Test (not pooled)	$t = (\bar{x}_1 - \bar{x}_2)/\sqrt{\mathrm{s}_{x1}^2/n_1 + \mathrm{s}_{x2}^2/n_2}$ $df = 1/(C^2/(n_1 - 1) + (1 - C)^2/(n_2 - 1))$ $C = (\mathrm{s}_{x1}^2/n_1)/(\mathrm{s}_{x1}^2/n_1 + \mathrm{s}_{x2}^2/n_2)$
LinearReg *t* Test	$b = \sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})/\sum_{i=1}^{n}(x_i - \bar{x})^2 \quad a = \bar{y} - b\bar{x}$ $t = r\sqrt{(n - 2)/(1 - r^2)}$
χ^2 GOF Test	$\chi^2 = \sum_{i}^{k}(O_i - E_i)^2/E_i$ O_i: The *i*-th element of the observed list E_i: The *i*-th element of the expected list
χ^2 two-way Test	$\chi^2 - \sum_{i}^{k}\sum_{j}^{\ell}(O_{ij} - E_{ij})^2/E_{ij}$ $E_{ij} = \sum_{i=1}^{k}O_{ij} \cdot \sum_{j=1}^{\ell}O_{ij} / \sum_{i=1}^{k}\sum_{j=1}^{\ell}O_{ij}$ O_{ii}: The element at row *i*. column *j* of the observed matrix E_{ij}: The element at row *i*, column *j* of the expected matrix
2-Sample *F* Test	$F = \mathrm{s}_{x1}^2/\mathrm{s}_{x2}^2$
ANOVA Test	$F = MS/MSe \quad MS = SS/Fdf \quad MSe = SSe/Edf$ $SS = \sum_{i=1}^{k}n_i(\bar{x}_i - \bar{x})^2 \quad SSe = \sum_{i=1}^{k}(n_i - 1)\mathrm{s}_{xi}^2$ $Fdf = k - 1 \quad Edf = \sum_{i=1}^{k}(n_i - 1)$

Confidence Interval

Confidence Interval	Left: confidence interval lower limit (left edge) Right: confidence interval upper limit (right edge)
1-Sample Z Interval	$Left, Right = \bar{x} \mp Z(\alpha/2) \cdot \sigma/\sqrt{n}$
2-Sample Z Interval	$Left, Right = (\bar{x}_1 - \bar{x}_2) \mp Z(\alpha/2)\sqrt{\sigma_1^2/n_1 + \sigma_2^2/n_2}$
1-Prop Z Interval	$Left, Right = x/n \mp Z(\alpha/2)\sqrt{1/n \cdot (x/n \cdot (1 - x/n))}$
2-Prop Z Interval	$Left, Right = (x_1/n_1 - x_2/n_2)$ $\mp Z(\alpha/2)\sqrt{(x_1/n_1 \cdot (1 - x_1/n_1))/n_1 + (x_2/n_2 \cdot (1 - x_2/n_2))/n_2}$
1-Sample t Interval	$Left, Right = \bar{x} \mp t_{n-1}(\alpha/2) \cdot s_x/\sqrt{n}$
2-Sample t Interval (pooled)	$Left, Right = (\bar{x}_1 - \bar{x}_2) \mp t_{n_1+n_2-2}(\alpha/2)\sqrt{s_p^2(1/n_1 + 1/n_2)}$ $s_p = \sqrt{((n_1 - 1)s_{x1}^2 + (n_2 - 1)s_{x2}^2)/(n_1 + n_2 - 2)}$
2-Sample t Interval (not pooled)	$Left, Right = (\bar{x}_1 - \bar{x}_2) \mp t_{df}(\alpha/2)\sqrt{s_{x1}^2/n_1 + s_{x2}^2/n_2}$ $df = 1/(C^2/(n_1 - 1) + (1 - C)^2/(n_2 - 1))$ $C = (s_{x1}^2/n_1)/(s_{x1}^2/n_1 + s_{x2}^2/n_2)$

α: level of significance $\alpha = 1 - [\text{C-Level}]$ C-Level: confidence level ($0 \leqq \text{C-Level} < 1$)
$Z(\alpha/2)$: upper $\alpha/2$ point of standard normal distribution
$t_{df}(\alpha/2)$: upper $\alpha/2$ point of t distribution with df degrees of freedom

Distribution (Continuous)

Distribution	**Probability Density**	**Cumulative Distribution**
Normal Distribution	$p(x) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$ $(\sigma > 0)$	$p = \int_{Lower}^{Upper} p(x)dx$
Student-t Distribution	$p(x) = \frac{\Gamma\left(\frac{df+1}{2}\right)}{\Gamma\left(\frac{df}{2}\right)} \times \frac{\left(1 + \frac{x^2}{df}\right)^{-\frac{df+1}{2}}}{\sqrt{\pi \times df}}$	
χ^2 Distribution	$p(x) = \frac{1}{\Gamma\left(\frac{df}{2}\right)} \times \left(\frac{1}{2}\right)^{\frac{df}{2}} \times x^{\left(\frac{df}{2}-1\right)} \times e^{-\frac{x}{2}}$ $(x \geqq 0)$	
F Distribution	$p(x) = \frac{\Gamma\left(\frac{ndf+ddf}{2}\right)}{\Gamma\left(\frac{ndf}{2}\right) \times \Gamma\left(\frac{ddf}{2}\right)} \left(\frac{ndf}{ddf}\right)^{\frac{ndf}{2}} x^{\frac{ndf}{2}-1} \left(1 + \frac{ndf \times x}{ddf}\right)^{-\frac{ndf+ddf}{2}}$ $(x \geqq 0)$	

Distribution	Inverse Cumulative Distribution
Normal Distribution	$p = \int_{-\infty}^{Upper} p(x)dx$ tail = Left $p = \int_{Lower}^{\infty} p(x)dx$ tail = Right $p = \int_{Lower}^{Upper} p(x)dx$ tail = Central
Student-*t* Distribution	$p = \int_{Lower}^{\infty} p(x)dx$
χ^2 Distribution	
F Distribution	

■ Distribution (Discrete)

Distribution	Probability
Binomial Distribution	$p(x) = {}_nC_x p^x(1-p)^{n-x}$ $(x = 0, 1, \cdots\cdots, n)$ n: number of trials
Poisson Distribution	$p(x) = \dfrac{e^{-\mu} \times \mu^x}{x!}$ $(x = 0, 1, 2, \cdots)$ μ: mean $(\mu > 0)$
Geometric Distribution	$p(x) = p(1-p)^{x-1}$ $(x = 1, 2, 3, \cdots)$
Hypergeometric Distribution	$p(x) = \dfrac{{}_MC_x \times {}_{N-M}C_{n-x}}{{}_NC_n}$ n: Number of elements extracted from population ($0 \leqq x$ integer) M: Number of elements contained in attribute A ($0 \leqq M$ integer) N: Number of population elements ($n \leqq N$, $M \leqq N$ integer)

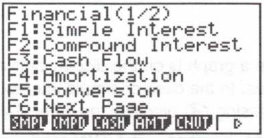
Distribution	Cumulative Distribution	Inverse Cumulative Distribution
Binomial Distribution	$p = \sum_{x=0}^{X} p(x)$	$p \leq \sum_{x=0}^{X} p(x)$
Poisson Distribution		
Geometric Distribution	$p = \sum_{x=1}^{X} p(x)$	$p \leq \sum_{x=1}^{X} p(x)$
Hypergeometric Distribution	$p = \sum_{x=0}^{X} p(x)$	$p \leq \sum_{x=0}^{X} p(x)$

Chapter 7 Financial Calculation (TVM)

1. Before Performing Financial Calculations

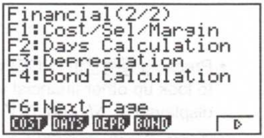
From the Main Menu, enter the **TVM** mode and display the Financial screen like the one shown below.

Financial 1 screen



```
Financial(1/2)
F1:Simple Interest
F2:Compound Interest
F3:Cash Flow
F4:Amortization
F5:Conversion
F6:Next Page
SMPL CMPD CASH AMT CNVT ▷
```

Financial 2 screen



```
Financial(2/2)
F1:Cost/Sel/Margin
F2:Days Calculation
F3:Depreciation
F4:Bond Calculation

F6:Next Page
COST DAYS DEPR BOND ▷
```

- {**SMPL**} ... {simple interest}
- {**CMPD**} ... {compound interest}
- {**CASH**} ... {cash flow (investment appraisal)}
- {**AMT**} ... {amortization}
- {**CNVT**} ... {interest rate conversion}
- {**COST**} ... {cost, selling price, margin}
- {**DAYS**} ... {day/date calculations}
- {**DEPR**} ... {depreciation calculations}
- {**BOND**} ... {bond calculations}

Setup Items

- **Payment**
  - {**BGN**}/{**END**} ... Specifies {beginning of the period}/{end of the period} payment
- **Date Mode**
  - {**365**}/{**360**} ... Specifies calculation according to a {365-day}/{360-day} year
- **Periods/YR. (payment interval specification)**
  - {**Annu**}/{**Semi**} ... {annual}/{semiannual}

Note the following points regarding Setup screen settings whenever using the **TVM** mode.

- The following graph Setup screen settings are all turned off for graphing in the **TVM** mode: Axes, Grid, Dual Screen.
- Drawing a financial graph while the Label item is turned on, displays the label CASH for the vertical axis (deposits, withdrawals), and TIME for the horizontal axis (frequency).

■ Graphing in the TVM Mode

After performing a financial calculation, you can use F6 (GRPH) to graph the results as shown below.

- Pressing SHIFT F1 (TRCE) while a graph is on the display activates Trace, which can be used to look up other financial values. In the case of simple interest, for example, pressing ▶ displays *PV*, *SI*, and *SFV*. Pressing ◀ displays the same values in reverse sequence.
- Zoom, Scroll, and Sketch cannot be used in the **TVM** mode.
- Whether you should use a positive or a negative value for the present value (PV) or the purchase price (PRC) depends on the type of calculation you are trying to perform.
- Note that graphs should be used only for reference purposes when viewing **TVM** mode calculation results.
- Note that calculation results produced in this mode should be regarded as reference values only.
- Whenever performing an actual financial transaction, be sure to check any calculation results obtained using this calculator with against the figures calculated by your financial institution.

2. Simple Interest

This calculator uses the following formulas to calculate simple interest.

• Formula

365-day Mode $SI' = \frac{n}{365} \times PV \times i \quad \left(i = \frac{I\%}{100}\right)$

360-day Mode $SI' = \frac{n}{360} \times PV \times i \quad \left(i = \frac{I\%}{100}\right)$

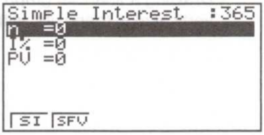
$$SI = -SI'$$
$$SFV = -(PV + SI')$$

SI : interest
n : number of interest periods
PV : principal
$I\%$: annual interest
SFV : principal plus interest

Press F1 (SMPL) from the Financial 1 screen to display the following input screen for simple interest.

F1 (SMPL)

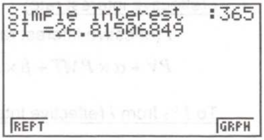
n .... number of interest periods (days)
I% .... annual interest rate
PV .... principal



```
Simple Interest  :365
n  =0
I% =0
PV =0
```

After configuring the parameters, use one of the function menus noted below to perform the corresponding calculation.

- {**SI**} … {simple interest}
- {**SFV**} … {simple future value}

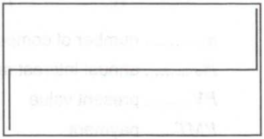


```
Simple Interest :365
SI =26.81506849



REPT                GRPH
```

- An error (Ma ERROR) occurs if parameters are not configured correctly.

Use the following function menus to maneuver between calculation result screens.

- {**REPT**} … {parameter input screen}
- {**GRPH**} … {draws graph}



After drawing a graph, you can press SHIFT F1(TRCE) to turn on trace and read calculation results along the graph.

Each press of ▶ while trace is turned on cycles the displayed value in the sequence: present value (PV) → simple interest (SI) → simple future value (SFV). Pressing ◀ cycles in the reverse direction.

Press EXIT to return to the parameter input screen.

3. Compound Interest

This calculator uses the following standard formulas to calculate compound interest.

• PV, PMT, FV, *n*

$I\% \neq 0$

$$PV = -(\alpha \times PMT + \beta \times FV) \qquad PMT = -\frac{PV + \beta \times FV}{\alpha}$$

$$FV = -\frac{PV + \alpha \times PMT}{\beta} \qquad n = \frac{\log\left\{\dfrac{(1+iS)\times PMT - FV \times i}{(1+iS)\times PMT + PV \times i}\right\}}{\log(1+i)}$$

$I\% = 0$

$$PV = -(PMT \times n + FV) \qquad PMT = -\frac{PV + FV}{n}$$

$$FV = -(PMT \times n + PV) \qquad n = -\frac{PV + FV}{PMT}$$

$$\alpha = (1 + i \times S) \times \frac{1-\beta}{i}, \quad \beta = (1+i)^{-n}$$

$$S = \begin{cases} 0 \text{ ....Payment : End (Setup Screen)} \\ 1 \text{ ....Payment : Begin (Setup Screen)} \end{cases} \qquad i = \begin{cases} \dfrac{I\%}{100} \text{ .... } (P/Y = C/Y = 1) \\ \left(1 + \dfrac{I\%}{100 \times [C/Y]}\right)^{\frac{C/Y}{P/Y}} - 1 \text{ ..... (Other than those above)} \end{cases}$$

• I %

i (effective interest rate)

i (effective interest rate) is calculated using Newton's Method.

$$PV + \alpha \times PMT + \beta \times FV = 0$$

To I % from i (effective interest rate)

$$I\% = \begin{cases} i \times 100 \text{ .... } (P/Y = C/Y = 1) \\ \left\{ (1+i)^{\frac{P/Y}{C/Y}} - 1 \right\} \times C/Y \times 100 \text{... (Other than those above)} \end{cases}$$

n .... number of compound periods

$I\%$ .... annual interest rate

PV .... present value

PMT ...... payment

FV .... future value

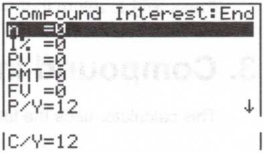
P/Y .... installment periods per year

C/Y .... compounding periods per year

- A deposit is indicated by a plus sign (+), while a withdrawal is indicated by a minus sign (–).

Press F2 (CMPD) from the Financial 1 screen to display the following input screen for compound interest.

F2 (CMPD)



```
Compound Interest:End
n  =0
I% =0
PV =0
PMT=0
FV =0
P/Y=12
C/Y=12
```

n .... number of compound periods

$I\%$ .... annual interest rate

PV .... present value (loan amount in case of loan; principal in case of savings)

PMT ..... payment for each installment (payment in case of loan; deposit in case of savings)

FV .... future value (unpaid balance in case of loan; principal plus interest in case of savings)

P/Y .... installment periods per year

C/Y .... compounding periods per year

Important!

Inputting Values

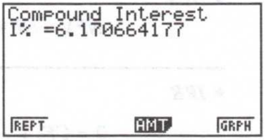
A period (n) is expressed as a positive value. Either the present value (PV) or future value (FV) is positive, while the other (PV or FV) is negative.

Precision

This calculator performs interest calculations using Newton's Method, which produces approximate values whose precision can be affected by various calculation conditions. Because of this, interest calculation results produced by this calculator should be used keeping the above limitation in mind or the results should be verified.

After configuring the parameters, use one of the function menus noted below to perform the corresponding calculation.

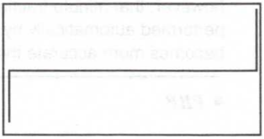
- {**n**} … {number of compound periods}
- {**I%**} … {annual interest rate}
- {**PV**} … {present value} (Loan: loan amount; Savings: balance)
- {**PMT**} … {payment} (Loan: installment; Savings: deposit)
- {**FV**} … {future value} (Loan: unpaid balance; Savings: principal plus interest)
- {**AMT**} … {amortization screen}


Compound Interest
I% =6.170664177

- An error (Ma ERROR) occurs if parameters are not configured correctly.

Use the following function menus to maneuver between calculation result screens.

- {**REPT**} … {parameter input screen}
- {**AMT**} … {amortization screen}
- {**GRPH**} … {draws graph}



After drawing a graph, you can press SHIFT F1(TRCE) to turn on trace and read calculation results along the graph.

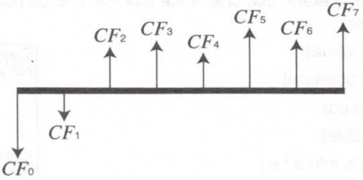
Press EXIT to return to the parameter input screen.

4. Cash Flow (Investment Appraisal)

This calculator uses the discounted cash flow (DCF) method to perform investment appraisal by totalling cash flow for a fixed period. This calculator can perform the following four types of investment appraisal.

- Net present value (*NPV*)
- Net future value (*NFV*)
- Internal rate of return (*IRR*)
- Payback period (*PBP*)

A cash flow diagram like the one shown below helps to visualize the movement of funds.



With this graph, the initial investment amount is represented by CF_0. The cash flow one year later is shown by CF_1, two years later by CF_2, and so on.

Investment appraisal can be used to clearly determine whether an investment is realizing profits that were originally targeted.

- ***NPV***

$$NPV = CF_0 + \frac{CF_1}{(1+i)} + \frac{CF_2}{(1+i)^2} + \frac{CF_3}{(1+i)^3} + \dots + \frac{CF_n}{(1+i)^n} \qquad \left(i = \frac{I\%}{100} \right)$$

n: natural number up to 254

- ***NFV***

$$NFV = NPV \times (1+i)^n$$

- ***IRR***

$$0 = CF_0 + \frac{CF_1}{(1+i)} + \frac{CF_2}{(1+i)^2} + \frac{CF_3}{(1+i)^3} + \dots + \frac{CF_n}{(1+i)^n}$$

In this formula, $NPV = 0$, and the value of IRR is equivalent to $i \times 100$. It should be noted, however, that minute fractional values tend to accumulate during the subsequent calculations performed automatically by the calculator, so NPV never actually reaches exactly zero. IRR becomes more accurate the closer that NPV approaches to zero.

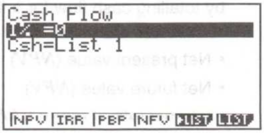
- ***PBP***

$$PBP = \begin{cases} 0 \ \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \ (CF_0 \geqq 0) \\ n - \dfrac{NPV_n}{NPV_{n+1} - NPV_n} \ \dots \ \text{(Other than those above)} \end{cases} \qquad NPV_n = \sum_{k=0}^{n} \frac{CF_k}{(1+i)^k}$$

n: smallest positive integer that satisfies the conditions $NPV_n \leqq 0$, $NPV_{n+1} \geqq 0$, or 0

Press F3(CASH) from the Financial 1 screen to display the following input screen for Cash Flow.

F3(CASH)


Cash Flow
I% =0
Csh=List 1

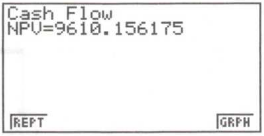
I% .... interest rate

Csh .... list for cash flow

If you have not yet input data into a list, press F5(▶LIST) and input data into a list.

After configuring the parameters, use one of the function menus noted below to perform the corresponding calculation.

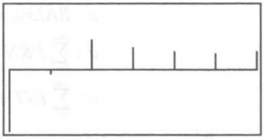
- {**NPV**} ... {net present value}
- {**IRR**} ... {internal rate of return}
- {**PBP**} ... {payback period}
- {**NFV**} ... {net future value}
- {**▶LIST**} ... {inputs data into a list}
- {**LIST**} ... {specifies a list for data input}


Cash Flow
NPV=9610.156175

- An error (Ma ERROR) occurs if parameters are not configured correctly.

Use the following function menus to maneuver between calculation result screens.

- {**REPT**} ... {parameter input screen}
- {**GRPH**} ... {draws graph}



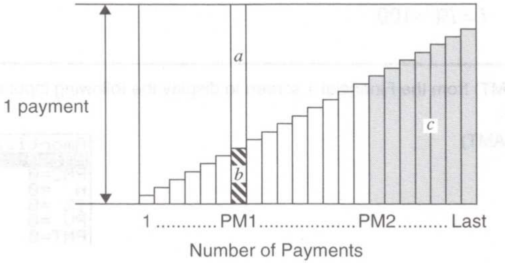
After drawing a graph, you can press SHIFT F1(TRCE) to turn on trace and read calculation results along the graph.

Press EXIT to return to the parameter input screen.

5. Amortization

This calculator can be used to calculate the principal and interest portion of a monthly installment, the remaining principal, and amount of principal and interest repaid up to any point.

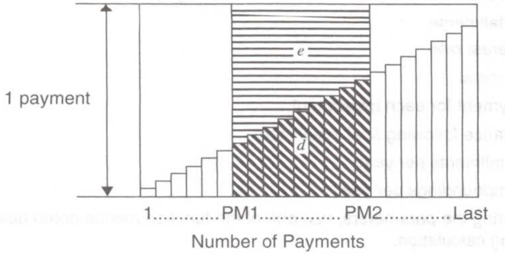
• Formula



a: interest portion of installment PM1 (INT)

b: principal portion of installment PM1 (PRN)

c: balance of principal after installment PM2 (BAL)



d: total principal from installment PM1 to payment of installment PM2 (ΣPRN)

e: total interest from installment PM1 to payment of installment PM2 (ΣINT)

$^*a + b$ = one repayment (PMT)

$$a : INT_{PM1} = |\,BAL_{PM1-1} \times i\,| \times (PMT \text{ sign})$$

$$b : PRN_{PM1} = PMT + BAL_{PM1-1} \times i$$

$$c : BAL_{PM2} = BAL_{PM2-1} + PRN_{PM2}$$

$$d : \sum_{PM1}^{PM2} PRN = PRN_{PM1} + PRN_{PM1+1} + \ldots + PRN_{PM2}$$

$$e : \sum_{PM1}^{PM2} INT = INT_{PM1} + INT_{PM1+1} + \ldots + INT_{PM2}$$

$BAL_0 = PV$ ($INT_1 = 0$ and $PRN_1 = PMT$ at beginning of installment term)

• Converting between the nominal interest rate and effective interest rate

The nominal interest rate ($I\%$ value input by user) is converted to an effective interest rate ($I\%'$) for installment loans where the number of installments per year is different from the number of compound interest calculation periods.

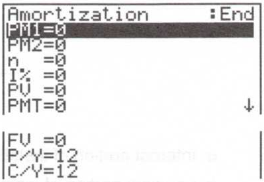
$$I\%' = \left\{ \left(1 + \frac{I\%}{100 \times [C/Y]}\right)^{\frac{[C/Y]}{[P/Y]}} - 1 \right\} \times 100$$

The following calculation is performed after conversion from the nominal interest rate to the effective interest rate, and the result is used for all subsequent calculations.

$$i = I\%' \div 100$$

Press F4 (AMT) from the Financial 1 screen to display the following input screen for amortization.

F4 (AMT)



```
Amortization      :End
PM1=0
PM2=0
n  =0
I% =0
PV =0
PMT=0                 ↓

FV =0
P/Y=12
C/Y=12
```

PM1....... first installment of installments 1 through n

PM2....... second installment of installments 1 through n

n .... installments

$I\%$ .... interest rate

PV .... principal

PMT ..... payment for each installment

FV .... balance following final installment

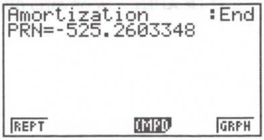
P/Y .... installments per year

C/Y .... compoundings per year

After configuring the parameters, use one of the function menus noted below to perform the corresponding calculation.

- {**BAL**} … {balance of principal after installment PM2}
- {**INT**} … {interest portion of installment PM1}
- {**PRN**} … {principal portion of installment PM1}

- {ΣINT} … {total interest paid from installment PM1 to installment PM2}
- {ΣPRN} … {total principal paid from installment PM1 to installment PM2}
- {CMPD} … {compound interest screen}

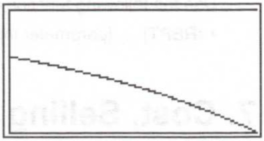


```
Amortization      :End
PRN=-525.2603348
```

- An error (Ma ERROR) occurs if parameters are not configured correctly.

Use the following function menus to maneuver between calculation result screens.

- {**REPT**} … {parameter input screen}
- {**CMPD**} … {compound interest screen}
- {**GRPH**} … {draws graph}



After drawing a graph, you can press SHIFT F1(TRCE) to turn on trace and read calculation results along the graph.

The first press of SHIFT F1(TRCE) displays *INT* and *PRN* when $n = 1$. Each press of ▶ shows *INT* and *PRN* when $n = 2$, $n = 3$, and so on.

Press EXIT to return to the parameter input screen.

6. Interest Rate Conversion

The procedures in this section describe how to convert between the annual percentage rate and effective interest rate.

• Formula

$$EFF = \left[\left(1+\frac{APR/100}{n}\right)^{n}-1\right]\times 100$$

$$APR = \left[\left(1+\frac{EFF}{100}\right)^{\frac{1}{n}}-1\right]\times n\times 100$$

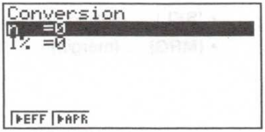
APR : annual percentage rate (%)
EFF : effective interest rate (%)
n : number of compoundings

Press F5(CNVT) from the Financial 1 screen to display the following input screen for interest rate conversion.

F5(CNVT)

n .... number of compoundings

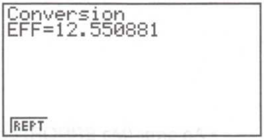
I% .... interest rate



```
Conversion
n  =0
I% =0
```

After configuring the parameters, use one of the function menus noted below to perform the corresponding calculation.

- {**▶EFF**} … {converts annual percentage rate to effective interest rate}
- {**▶APR**} … {converts effective interest rate to annual percent rate}


Conversion
EFF=12.550881

- An error (Ma ERROR) occurs if parameters are not configured correctly.

Use the following function menu to maneuver between calculation result screens.

- {**REPT**} … {parameter input screen}

7. Cost, Selling Price, Margin

Cost, selling price, or margin can be calculated by inputting the other two values.

• Formula

$$CST = SEL\left(1-\frac{MRG}{100}\right)$$

$$SEL = \frac{CST}{1-\dfrac{MRG}{100}}$$

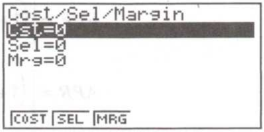
$$MRG(\%) = \left(1-\frac{CST}{SEL}\right)\times 100$$

CST : cost
SEL : selling price
MRG : margin

Press F1(COST) from the Financial 2 screen to display the following input screen.

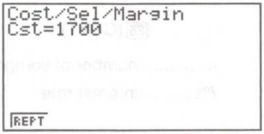
F6(▷)F1(COST)

Cst......... cost
Sel......... selling price
Mrg........ margin


Cost/Sel/Margin
Cst=0
Sel=0
Mrg=0

After configuring the parameters, use one of the function menus noted below to perform the corresponding calculation.

- {**COST**} … {cost}
- {**SEL**} … {selling price}
- {**MRG**} … {margin}


Cost/Sel/Margin
Cst=1700

- An error (Ma ERROR) occurs if parameters are not configured correctly.

Use the following function menu to maneuver between calculation result screens.

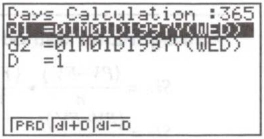
- {**REPT**} … {parameter input screen}

8. Day/Date Calculations

You can calculate the number of days between two dates, or you can determine what date comes a specific number of days before or after another date.

Press F2(DAYS) from the Financial 2 screen to display the following input screen for day/date calculation.

F6(▷)F2(DAYS)



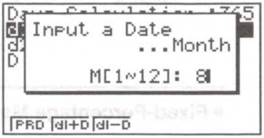
```
Days Calculation :365
d1 =01M01D1997Y(WED)
d2 =01M01D1997Y(WED)
D  =1
```

d1.......... date 1

d2.......... date 2

D .... number of days

To input a date, first highlight d1 or d2. Pressing a number key to input the month causes an input screen like the one shown below to appear on the display.



```
Input a Date
       ...Month

    M[1~12]: 8
```

Input the month, day, and year, pressing EXE after each.

After configuring the parameters, use one of the function menus noted below to perform the corresponding calculation.

- {**PRD**} … {number of days from d1 to d2 (d2 – d1)}
- {**d1+D**} … {d1 plus a number of days (d1 + D)}
- {**d1–D**} … {d1 minus a number of days (d1 – D)}

- An error (Ma ERROR) occurs if parameters are not configured correctly.

Use the following function menu to maneuver between calculation result screens.

- {**REPT**} … {parameter input screen}

- The Setup screen can be used to specify either a 365-day or 360-day year for financial calculations. Day/date calculations are also performed in accordance with the current setting for number of days in the year, but the following calculations cannot be performed when the 360-day year is set. Attempting to do so causes an error.

  (Date) + (Number of Days)

  (Date) – (Number of Days)

- The allowable calculation range is January 1, 1901 to December 31, 2099.

• 360-day Date Mode Calculations

The following describes how calculations are processed when 360 is specified for the Date Mode item in the Setup screen.

- If d1 is day 31 of a month, d1 is treated as day 30 of that month is used.
- If d2 is day 31 of a month, d2 is treated as day 1 of the following month, unless d1 is day 30.

9. Depreciation

Depreciation lets you calculate the amount that a business expense can be offset by income (depreciated) over a given year.

- This calculator supports the following four types of depreciation calculations. straight-line (*SL*), fixed-percentage (*FP*), sum-of-the-years'-digits (*SYD*), or declining-balance (*DB*).
- Any one of the above methods can be used to calculate depreciation for a specified period. A table and graph of the depreciated amount and undepreciated amount in year *j*.

• Straight-Line Method (SL)

$$SL_1 = \frac{(PV-FV)}{n} \bullet \frac{\{Y-1\}}{12}$$

$$SL_j = \frac{(PV-FV)}{n}$$

$$SL_{n+1} = \frac{(PV-FV)}{n} \bullet \frac{12-\{Y-1\}}{12} \qquad (\{Y-1\}\neq 12)$$

SL_j : depreciation charge for the *j*th year
n : useful life
PV : original cost (basis)
FV : residual book value
j : year for calculation of depreciation cost
$Y-1$: number of months in the first year of depreciation

• Fixed-Percentage Method (FP)

$$FP_1 = PV \times \frac{I\%}{100} \times \frac{\{Y-1\}}{12}$$

$$FP_j = (RDV_{j-1} + FV) \times \frac{I\%}{100}$$

$$FP_{n+1} = RDV_n \qquad (\{Y-1\}\neq 12)$$

$$RDV_1 = PV - FV - FP_1$$

$$RDV_j = RDV_{j-1} - FP_j$$

$$RDV_{n+1} = 0 \qquad (\{Y-1\}\neq 12)$$

FP_j : depreciation charge for the *j*th year
RDV_j : remaining depreciable value at the end of *j*th year
$I\%$: depreciation ratio

• Sum-of-the-Years'-Digits Method (SYD)

$$Z = \frac{n(n+1)}{2} \qquad n' = n - \frac{\{Y-1\}}{12}$$

$$Z' = \frac{(n'\text{ integer part }+1)(n'\text{ integer part }+2{*}n'\text{ fraction part})}{2}$$

$$SYD_1 = \frac{n}{Z} \times \frac{\{Y-1\}}{12}(PV-FV)$$

$$SYD_j = \left(\frac{n'-j+2}{Z'}\right)(PV-FV-SYD_1) \qquad (j\neq 1)$$

$$SYD_{n+1} = \left(\frac{n'-(n+1)+2}{Z'}\right)(PV-FV-SYD_1) \times \frac{12-\{Y-1\}}{12} \qquad (\{Y-1\}\neq 12)$$

$$RDV_1 = PV - FV - SYD_1$$

$$RDV_j = RDV_{j-1} - SYD_j$$

SYD_j : depreciation charge for the *j*th year
RDV_j : remaining depreciable value at the end of *j*th year

• Declining-Balance Method (DB)

$$DB_1 = PV \times \frac{I\%}{100n} \times \frac{Y-1}{12}$$

$$RDV_1 = PV - FV - DB_1$$

$$DB_j = (RDV_{j-1} + FV) \times \frac{I\%}{100n}$$

$$RDV_j = RDV_{j-1} - DB_j$$

$$DB_{n+1} = RDV_n \qquad (\{Y-1\} \neq 12)$$

$$RDV_{n+1} = 0 \qquad (\{Y-1\} \neq 12)$$

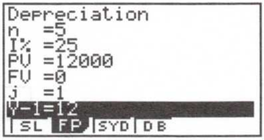
DB_j : depreciation charge for the *j*th year

RDV_j : remaining depreciable value at the end of *j*th year

$I\%$: depreciation factor

Press F3(DEPR) from the Financial 2 screen to display the following input screen for depreciation calculation.

F6(▷)F3(DEPR)



```
Depreciation
n   =5
I%  =25
PV  =12000
FV  =0
j   =1
Y-1=12
```

n .... useful life

I% .... depreciation ratio in the case of the fixed percent (FP) method, depreciation factor in the case of the declining balance (DB) method

PV .... original cost (basis)

FV .... residual book value

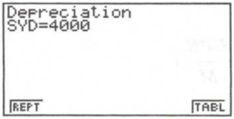
j .... year for calculation of depreciation cost

Y−1........ number of months in the first year of depreciation

After configuring the parameters, use one of the function menus noted below to perform the corresponding calculation.

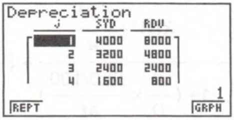
- {**SL**} … {Calculate depreciation for year *j* using the straight-line method}
- {**FP**} ... {**FP**} ....{Calculate depreciation for year *j* using the fixed-percentage method}
  {**I%**} .....{Calculate depreciation ratio}
- {**SYD**} … {Calculate depreciation for year *j* using the sum-of-the-years'-digits method}
- {**DB**} … {Calculate depreciation for year *j* calculated using the declining-balance method}

Calculation Result Output Examples



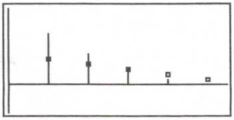
```
Depreciation
SYD=4000
```

{SYD}



```
Depreciation
         j      SYD     RDV
         1     4000    8000
         2     3200    4800
         3     2400    2400
         4     1600     800
```

{SYD} – {TABL}



{SYD} – {GRPH}

An error (Ma ERROR) occurs if parameters are not configured correctly.

Use the following function menu to maneuver between calculation result screens.

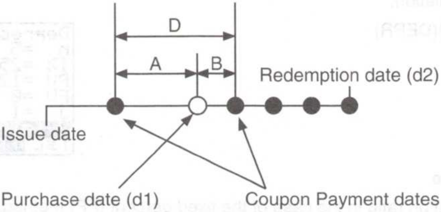
- {**REPT**} ... {parameter input screen}
- {**TABL**} ... {displays table}
- {**GRPH**} ... {draws graph}

10. Bond Calculations

Bond calculation lets you calculate the purchase price or the annual yield of a bond.

Before starting bond calculations, use the Setup screen to configure "Date Mode" and "Periods/YR." settings (page 7-1).

• Formula



PRC : price per $100 of face value

CPN : annual coupon rate (%)

YLD : yield to maturity (%)

A : accrued days

M : number of coupon payments per year (1=annual, 2=semi annual)

N : number of coupon payments between settlement date and maturity date

RDB : redemption price or call price per $100 of face value

D : number of days in coupon period where settlement occurs

B : number of days from settlement date until next coupon payment date = D – A

INT : accrued interest

CST : price including interest

• Price per $100 of face value (PRC)

- For one or fewer coupon period to redemption

$$PRC = -\frac{RDV + \frac{CPN}{M}}{1 + (\frac{B}{D} \times \frac{YLD/100}{M})} + (\frac{A}{D} \times \frac{CPN}{M})$$

- For more than one coupon period to redemption

$$PRC = -\frac{RDV}{\left(1+\frac{YLD/100}{M}\right)^{(N-1+B/D)}} - \sum_{k=1}^{N}\frac{\frac{CPN}{M}}{\left(1+\frac{YLD/100}{M}\right)^{(k-1+B/D)}} + \frac{A}{D}\times\frac{CPN}{M}$$

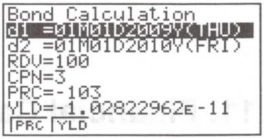
$$INT = -\frac{A}{D}\times\frac{CPN}{M} \qquad CST = PRC + INT$$

• Annual Yield (YLD)

YLD is calculated using Newton's Method.

Press F4(BOND) from the Financial 2 screen to display the following input screen for Bond calculation.

F6(▷)F4(BOND)



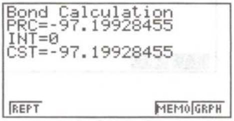
Bond Calculation
d1 =01M01D2009Y(THU)
d2 =01M01D2010Y(FRI)
RDV=100
CPN=3
PRC=-103
YLD=-1.02822962E-11

d1.......... purchase date (month, date, year)
d2.......... redemption date (month, date, year)
RDV...... redemption price per $100 of face value
CPN...... coupon rate
PRC...... price per $100 of face value
YLD...... annual yield

After configuring the parameters, use one of the function menus noted below to perform the corresponding calculation.

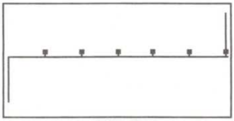
- {**PRC**} … {Calculate the bond's price (PRC), accrued interest (INT), and cost of bond (CST)}
- {**YLD**} … {Calculate the yield to maturity}

Calculation Result Output Examples

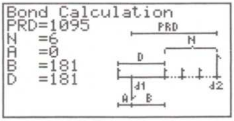


Bond Calculation
PRC=-97.19928455
INT=0
CST=-97.19928455

{PRC}



{PRC} – {GRPH}



Bond Calculation
PRD=1095
N =6
A =0
B =181
D =181

{PRC} – {MEMO}

An error (Ma ERROR) occurs if parameters are not configured correctly.

Use the following function menu to maneuver between calculation result screens.

- {**REPT**} … {parameter input screen}
- {**GRPH**} … {draws graph}
- {**MEMO**} … {displays numbers of days used in calculations}

MEMO Screen

- The following describes the meaning of the MEMO screen display items.

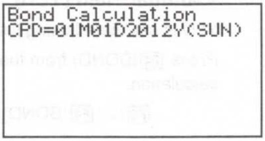
  PRD ... number of days from d1 to d2

  N......... number of coupon payments between settlement date and maturity date

  A......... accrued days

  B......... number of days from settlement date until next coupon payment date (D–A)

  D .... number of days in coupon period where settlement occurs
- Each press of EXE while the MEMO screen is displayed cycles the Coupon Payment Day (CPD) display sequentially from the redemption year up to the purchase year. This is true only when the "Date Mode" setting on the "Setup" screen is "365".



```
Bond Calculation
CPD=01M01D2012Y(SUN)
```

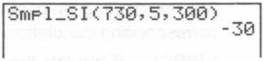
11. Financial Calculations Using Functions

You can use special functions in the **RUN•MAT** mode or **PRGM** mode to perform calculations that are the same as the **TVM** mode financial calculations.

Example **To calculate the total interest and principal paid for a 2-year (730-day) $300 loan at a simple annual interest rate of 5%. Use a Date Mode setting of 365.**

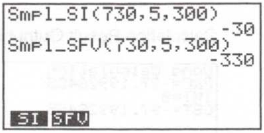
1. From the Main Menu, enter the **RUN•MAT** mode.
2. Press the keys as follows.

   OPTN F6(▷) F6(▷) F6(▷) F1(TVM) F1(SMPL) F1(SI) 7 3 0 , 5 , 3 0 0) EXE



```
SmPl_SI(730,5,300)
                -30
```

   F2(SFV) 7 3 0 , 5 , 3 0 0) EXE



```
SmPl_SI(730,5,300)
                -30
SmPl_SFV(730,5,300)
               -330
```

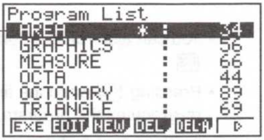
- Use the **TVM** mode Setup screen (SHIFT MENU (SET UP)) to change the Date Mode setting. You also can use special commands (DateMode365, DateMode360) in the **PRGM** mode to change the setting.
- For details about what you can do with the financial calculation functions and their syntax, see "Performing Financial Calculations in a Program" (page 8-35).

Chapter 8 Programming

1. Basic Programming Steps

Commands and calculations are executed sequentially, just like manual calculation multistatements.

1. From the Main Menu, enter the **PRGM** mode. When you do, a program list appears on the display.



Selected program area (use ▲ and ▼ to move)

```
Program List
AREA      * : 34
GRAPHICS    : 56
MEASURE     : 66
OCTA        : 44
OCTONARY    : 89
TRIANGLE    : 69
EXE EDIT NEW DEL DEL·A ▷
```

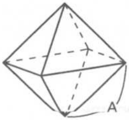
   Files are listed in the alphabetic sequence of their names.

2. Register a file name.
3. Input the program.
4. Run the program.

- The values to the right of the program list indicate the number of bytes used by each program.
- A file name can be up to eight characters long.
- The following are the characters you can use in a file name: A through Z, r, θ, spaces, [,], {, }, ', ", ~, 0 through 9, ., +, –, ×, ÷
- Registering a file name uses 32 bytes of memory.

Example **To calculate the surface area (cm²) and volume (cm³) of three regular octahedrons when the length of one side is 7, 10, and 15 cm, respectively**

Store the calculation formula under the file name OCTA.



The following are the formulas used for calculating surface area S and volume V of a regular octahedron for which the length of one side A is known.

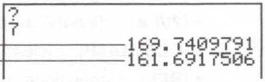
$$S = 2\sqrt{3}\,A^2, \quad V = \frac{\sqrt{2}}{3}A^3$$

① MENU PRGM

② F3(NEW) 9(O) ln(C) ÷(T) X,θ,T(A) EXE

③ SHIFT VARS(PRGM) F4(?) → ALPHA X,θ,T(A) F6(▷) F5(:)
2 × SHIFT x²(√‾) 3 × ALPHA X,θ,T(A) x² F6(▷) F6(▷) F5(◢)
SHIFT x²(√‾) 2 ÷ 3 × ALPHA X,θ,T(A) ∧ 3
EXIT EXIT

④ F1(EXE) or EXE
7 EXE(Value of A)
EXE



S when A = 7
V when A = 7

```
?
7
             169.7409791
             161.6917506
```

EXE EXE

1 0 EXE

EXE

```
                  ?
                  10
S when A = 10 ──────────────346.4101615
V when A = 10 ──────────────471.4045208
```

EXE EXE

1 5 EXE

EXE *1

```
                  ?
                  15
S when A = 15 ──────────────779.4228634
V when A = 15 ──────────────1590.990258
```

*1 Pressing EXE while the program's final result is on the display exits the program.

- You can also run a program while in the **RUN • MAT** mode by inputting: Prog "<file name>" EXE .
- Pressing EXE while the final result of a program executed using this method is on the display re-executes the program.
- An error occurs if the program specified by Prog "<file name>" cannot be found.

2. PRGM Mode Function Keys

- {**NEW**} ... {new program}

• When you are registering a file name

- {**RUN**}/{**BASE**} ... {general calculation}/{number base} program input
- {**⊶0**} ... {password registration}
- {**SYBL**} ... {symbol menu}

• When you are inputting a program —— F1 (RUN) ... default

- {**TOP**}/{**BTM**} ... {top}/{bottom} of program
- {**SRC**} ... {search}
- {**MENU**} ... {mode menu}
  - {**STAT**}/{**MAT**}/{**LIST**}/{**GRPH**}/{**DYNA**}/{**TABL**}/{**RECR**} ... {statistic}/{matrix}/{list}/{graph}/{Dynamic Graph}/{Table}/{recursion} menu
- {**A↔a**} ... {toggles between upper-case and lower-case input}
- {**CHAR**} ... {displays a screen for selecting various mathematical symbols, special symbols, and accented characters}

- Pressing SHIFT VARS (PRGM) displays the following program (PRGM) menu.
- {**COM**} ... {program command menu}
- {**CTL**} ... {program control command menu}
- {**JUMP**} ... {jump command menu}
- {**?**}/{**◢**} ... {input}/{output} command
- {**CLR**}/{**DISP**} ... {clear}/{display} command menu
- {**REL**} ... {conditional jump relational operator menu}
- {**I/O**} ... {I/O control/transfer command menu}

  - {:} ... {multi-statement command}
  - {STR} ... {string command}

See "Command Reference" on page 8-7 for full details on each of these commands.

- Pressing SHIFT MENU (SET UP) displays the mode command menu shown below.
  - **{ANGL}/{COOR}/{GRID}/{AXES}/{LABL}/{DISP}/{S/L}/{DRAW}/{DERV}/{BACK}/{FUNC}/ {SIML}/{S-WIN}/{LIST}/{LOCS}/{T-VAR}/{ΣDSP}/{RESID}/{CPLX}/{FRAC}/{Y • SPD}/ {DATE}/{PMT}/{PRD}/{INEQ}/{SIMP}/{Q1Q3}**

See "Setup Screen Function Key Menus" on page 1-14 for details about each of these commands.

• When you are inputting a program —— F2 (BASE)[1]

- **{TOP}/{BTM}/{SRC}**
- **{MENU}**
  - **{d~o}** ... {decimal}/{hexadecimal}/{binary}/{octal} value input
  - **{LOG}** ... {bitwise operator}
  - **{DISP}** ... conversion of displayed value to {decimal}/{hexadecimal}/{binary}/{octal}
- **{A↔a}/{SYBL}**

- Pressing SHIFT VARS (PRGM) displays the following PRGM (PROGRAM) menu.
  - **{Prog}** ... {program recall}
  - **{JUMP}/{?}/{◢}**
  - **{REL}** ... {conditional jump relational operator menu}
  - **{:}** ... {multi-statement command}

- Pressing SHIFT MENU (SET UP) displays the mode command menu shown below.
  - **{Dec}/{Hex}/{Bin}/{Oct}**

---

[1] Programs input after pressing F2 (BASE) are indicated by B to the right of the file name.

- **{EXE}/{EDIT}** ... program {execute}/{edit}
- **{NEW}** ... {new program}
- **{DEL}/{DEL • A}** ... {specific program}/{all program} delete
- **{SRC}/{REN}** ... file name {search}/{change}

3. Editing Program Contents

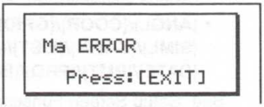
■ Debugging a Program

A problem in a program that keeps the program from running correctly is called a "bug", and the process of eliminating such problems is called "debugging". Either of the following symptoms indicates that your program contains bugs that require debugging.

- Error messages appearing when the program is run
- Results that are not within your expectations

• To eliminate bugs that cause error messages

An error message, like the one shown to the right, appears whenever something illegal occurs during program execution.



```
Ma ERROR

     Press:[EXIT]
```

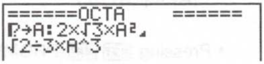
When such a message appears, press EXIT to display the place in the program where the error was caused. The cursor will be flashing at the location of the problem. Check the "Error Message Table" (page α-1) for steps you should take to correct the situation.

- Note that pressing EXIT does not display the location of the error if the program is password protected.

• To eliminate bugs that cause bad results

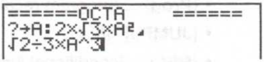
If your program produces results that are not what you normally expect, check the contents of the program and make necessary changes.

F1(TOP) ... Moves the cursor to the top of the program



```
======OCTA      ======
?→A:2×√3×A²↵
√2÷3×A^3
```

F2(BTM) ... Moves the cursor to the bottom of the program

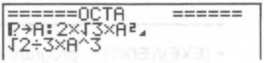


```
======OCTA      ======
?→A:2×√3×A²↵
√2÷3×A^3
```

■ Searching for Data Inside a Program

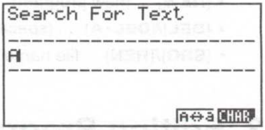
Example **To search for the letter "A" inside the program named OCTA**

1. Recall the program.
2. Press F3(SRC) and input the data you want to find.



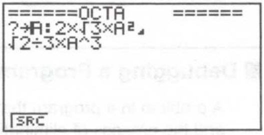
```
======OCTA      ======
?→A:2×√3×A²↵
√2÷3×A^3
```

F3(SRC)
ALPHA X,θ,T(A)



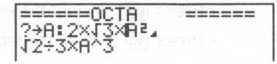
```
Search For Text
---------------------
A
---------------------
```

3. Press EXE to begin the search. The contents of the program appear on the screen with the cursor located at the first instance of the data you specified.*1



```
======OCTA      ======
?→A:2×√3×A²↵
√2÷3×A^3
```

4. Each press of EXE or F1(SRC) causes the cursor to jump to the next instance of the data you specified.*2



```
======OCTA      ======
?→A:2×√3×A²◢
√2÷3×A^3
```

*1 The message "Not Found" appears when the search data you specify cannot be found in the program.

*2 If there are no more instances of the data you specified, the search operation ends.

- You cannot specify the newline symbol (↵) or display command (◢) for the search data.
- Once the contents of the program are on the screen, you can use the cursor keys to move the cursor to another location before searching for the next instance of the data. Only the part of the program starting from the current cursor location is searched when you press EXE.
- Once the search finds an instance of your data, inputting characters or moving the cursor causes the search operation to be cancelled.
- If you make a mistake while inputting characters to search for, press AC to clear your input and re-input from the beginning.

4. File Management

Searching for a File

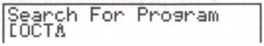
• To find a file using initial character search

Example **To use initial character search to recall the program named OCTA**

1. While the program list is on the display, press F6(▷)F1(SRC) and input the initial characters of the file you want to find.

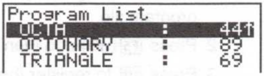
   F6(▷)F1(SRC)

   9(O)ln(C)÷(T)



```
Search For Program
[OCTA
```

2. Press EXE to search.
   - The name that starts with the characters you input highlights.



```
Program List
 OCTA         :   441
 OCTONARY     :    89
 TRIANGLE     :    69
```

- If there is no program whose file name starts with the characters you input, the message "Not Found" appears on the display. If this happens, press EXIT to clear the error message.

Editing a File Name

1. While the program list is on the display, use ⊚ and ⊚ to move the highlighting to the file whose name you want to edit and then press F6(▷)F2(REN).
2. Make any changes you want.
3. Press EXE to register the new name and return to the program list.

The program list is resorted according to the changes you made in the file name.

- If the modifications you make result in a file name that is identical to the name of a program already stored in memory, the message "Already Exists" appears. When this happens, you can perform either of the following two operations to correct the situation.

- Press EXIT to clear the error and return to the file name editing screen.
- Press AC to clear the input file name and input a new one.

■ Deleting a Program

• To delete a specific program

1. While the program list is on the display, use ▲ and ▼ to move the highlighting to the name of the program you want to delete.
2. Press F4 (DEL).
3. Press F1 (YES) to delete the selected program or F6 (NO) to abort the operation without deleting anything.

• To delete all programs

1. While the program list is on the display, press F5 (DEL•A).
2. Press F1 (YES) to delete all the programs in the list or F6 (NO) to abort the operation without deleting anything.

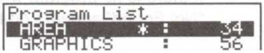
- You also can delete all programs by entering the **MEMORY** mode from the Main Menu. See "Chapter 9 Memory Manager" for details.

■ Registering a password

When inputting a program, you can protect it with a password that limits access to the program contents to those who know the password.

- You do not need to input the password to run a program.
- The password input procedure is identical to that used for file name input.

1. While the program list is on the display, press F3 (NEW) and input the file name of the new program file.
2. Press F5 (🔑) and then input the password.
3. Press EXE to register the file name and password. Now you can input the contents of the program file.
4. After inputting the program, press SHIFT EXIT (QUIT) to exit the program file and return to the program list. Files that are password protected are indicated by an asterisk to the right of the file name.



```
Program List
 AREA          * :    34
 GRAPHICS        :    56
```

■ Recalling a Password Protected Program

1. In the program list, use ▲ and ▼ to move the highlighting to the name of the program you want to recall.
2. Press F2 (EDIT).
3. Input the password and press EXE to recall the program.

- Inputting the wrong password when recalling a password protected program causes the message "Mismatch" to appear.

5. Command Reference

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The following are conventions that are used in this section when describing the various commands.

Boldface Text	Actual commands and other items that always must be input are shown in boldface.
{Curly Brackets}	Curly brackets are used to enclose a number of items, one of which must be selected when using a command. Do not input the curly brackets when inputting a command.
[Square Brackets]	Square brackets are used to enclose items that are optional. Do not input the square brackets when inputting a command.
Numeric Expressions	Numeric expressions (such as 10, 10 + 20, A) indicate constants, calculations, numeric constants, etc.
Alpha Characters	Alpha characters indicate literal strings (such as AB).

■ Basic Operation Commands

? (Input Command)

Function: Prompts for input of values for assignment to variables during program execution.

Syntax: ? → <variable name>, "<prompt>" ? → <variable name>

Example: ? → A↵

Description:

- This command momentarily interrupts program execution and prompts for input of a value or expression for assignment to a variable. If you do not specify a prompt, execution of this command causes "?" to appear indicating the calculator is standing by for input. If a prompt is specified, "<prompt>?" appears to prompt input. Up to 255 bytes of text can be used for a prompt.
- Input in response to the input command must be a value or an expression, and the expression cannot be a multi-statement.
- You can specify a list name, matrix name, string name, function memory (fn), graph (Yn), etc. as a variable name.

◢ (Output Command)

Function: Displays an intermediate result during program execution.

Description:

- This command momentarily interrupts program execution and displays alpha character text or the result of the calculation immediately before the command.
- The output command should be used at locations where you would normally press the EXE key during a manual calculation.

: (Multi-statement Command)

Function: Connects two statements for sequential execution without stopping.

Description:

- Unlike the output command (◢), statements connected with the multi-statement command are executed non-stop.
- The multi-statement command can be used to link two calculation expressions or two commands.
- You can also use a carriage return indicated by ↵ in place of the multi-statement command.

↵ (Carriage Return)

Function: Connects two statements for sequential execution without stopping.

Description:

- Operation of the carriage return is identical to that of the multi-statement command.
- You can create a blank line in a program by inputting a carriage return only. Using a carriage return in place of the multi-statement command makes the displayed program easier to read.

' (Comment Text Delimiter)

Function: Indicates comment text inserted inside a program.

Description: Anything following the apostrophe is treated as non-executable comment text.

■ Program Commands (COM)

If~Then~(Else~)IfEnd

Function: The Then-statement is executed only when the If-condition is true (non-zero). The Else-statement is executed when the If-condition is false (0). The IfEnd-statement is always executed following either the Then-statement or Else-statement.

Syntax:

$$\text{If} \quad \underset{\text{numeric expression}}{\underline{\text{<condition>}}} \begin{Bmatrix} \text{↵} \\ : \\ \text{◢} \end{Bmatrix} \text{Then <statement>} \left[\begin{Bmatrix} \text{↵} \\ : \\ \text{◢} \end{Bmatrix} \text{<statement>} \right]$$

$$\begin{Bmatrix} \text{↵} \\ : \\ \text{◢} \end{Bmatrix} \left(\text{Else <statement>} \left[\begin{Bmatrix} \text{↵} \\ : \\ \text{◢} \end{Bmatrix} \text{<statement>} \right] \begin{Bmatrix} \text{↵} \\ : \\ \text{◢} \end{Bmatrix} \right) \text{IfEnd}$$

Parameters: condition, numeric expression

Description:

(1) If ~ Then ~ IfEnd

- When the condition is true, execution proceeds with the Then-statement and then continues with the statement following IfEnd.
- When the condition is false, execution jumps to the statement following IfEnd.

(2) If ~ Then ~ Else ~ IfEnd

- When the condition is true, execution proceeds with the Then-statement and then jumps to the statement following IfEnd.
- When the condition is false, execution jumps to the Else-statement and then continues with the statement following IfEnd.

For~To~(Step~)Next

Function: This command repeats everything between the For-statement and the Next-statement. The starting value is assigned to the control variable with the first execution, and the value of the control variable is changed according to the step value with each execution. Execution continues until the value of the control variable exceeds the ending value.

Syntax: For <starting value> → <control variable name> To <ending value>

$$\left(\text{Step <step value>} \right) \begin{Bmatrix} \text{↵} \\ : \\ \text{◢} \end{Bmatrix} \text{Next}$$

Parameters:

- control variable name: A to Z
- starting value: value or expression that produces a value (i.e. sin x, A, etc.)
- ending value: value or expression that produces a value (i.e. sin x, A, etc.)
- step value: numeric value (default: 1)

Description:

- The default step value is 1.
- Making the starting value less than the ending value and specifying a positive step value causes the control variable to be incremented with each execution. Making the starting value greater than the ending value and specifying a negative step value causes the control variable to be decremented with each execution.

Do~LpWhile

Function: This command repeats specific commands as long as its condition is true (non-zero).

Syntax:

$$\text{Do}\left\{\begin{matrix}\hookleftarrow\\ :\\ \text{◢}\end{matrix}\right\}\langle\text{statement}\rangle\left\{\begin{matrix}\hookleftarrow\\ :\\ \text{◢}\end{matrix}\right\}\text{LpWhile}\quad \underset{\text{numeric expression}}{\underline{\langle\text{condition}\rangle}}$$

Parameters: expression

Description:

- This command repeats the commands contained in the loop as long as its condition is true (non-zero). When the condition becomes false (0), execution proceeds from the statement following the LpWhile-statement.
- Since the condition comes after the LpWhile-statement, the condition is tested (checked) after all of the commands inside the loop are executed.

While~WhileEnd

Function: This command repeats specific commands as long as its condition is true (non-zero).

Syntax:

$$\text{While}\quad \underset{\text{numeric expression}}{\underline{\langle\text{condition}\rangle}}\left\{\begin{matrix}\hookleftarrow\\ :\\ \text{◢}\end{matrix}\right\}\langle\text{statement}\rangle\left\{\begin{matrix}\hookleftarrow\\ :\\ \text{◢}\end{matrix}\right\}\text{WhileEnd}$$

Parameters: expression

Description:

- This command repeats the commands contained in the loop as long as its condition is true (non-zero). When the condition becomes false (0), execution proceeds from the statement following the WhileEnd-statement.
- Since the condition comes after the While-statement, the condition is tested (checked) before the commands inside the loop are executed.

■ Program Control Commands (CTL)

Break

Function: This command breaks execution of a loop and continues from the next command following the loop.

Syntax: Break ↵

Description:

- This command breaks execution of a loop and continues from the next command following the loop.
- This command can be used to break execution of a For-statement, Do-statement, and While-statement.

Prog

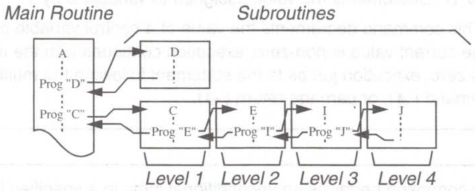
Function: This command specifies execution of another program as a subroutine. In the **RUN•MAT** mode, this command executes a new program.

Syntax: Prog "file name" ↵

Example: Prog "ABC" ↵

Description:

- Even when this command is located inside of a loop, its execution immediately breaks the loop and launches the subroutine.
- This command can be used as many times as necessary inside of a main routine to call up independent subroutines to perform specific tasks.
- A subroutine can be used in multiple locations in the same main routine, or it can be called up by any number of main routines.



- Calling up a subroutine causes it to be executed from the beginning. After execution of the subroutine is complete, execution returns to the main routine, continuing from the statement following the Prog command.
- A Goto~Lbl command inside of a subroutine is valid inside of that subroutine only. It cannot be used to jump to a label outside of the subroutine.
- If a subroutine with the file name specified by the Prog command does not exist, an error occurs.
- In the **RUN•MAT** mode, inputting the Prog command and pressing EXE launches the program specified by the command.

Return

Function: This command returns from a subroutine.

Syntax: Return ↵

Description: Execution of the Return command inside a main routine causes execution of the program to stop. Execution of the Return command within a subroutine terminates the subroutine and returns to the program from which the subroutine was jumped to.

Stop

Function: This command terminates execution of a program.

Syntax: Stop ↵

Description:

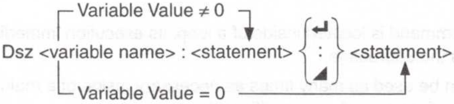
- This command terminates program execution.
- Execution of this command inside of a loop terminates program execution without an error being generated.

■ Jump Commands (JUMP)

Dsz

Function: This command is a count jump that decrements the value of a control variable by 1, and then jumps if the current value of the variable is zero.

Syntax:



Parameters: variable name: A to Z, *r*, *θ*

[Example] Dsz B : Decrements the value assigned to variable B by 1.

Description: This command decrements the value of a control variable by 1, and then tests (checks) it. If the current value is non-zero, execution continues with the next statement. If the current value is zero, execution jumps to the statement following the multi-statement command (:), display command (◢), or carriage return (↵).

Goto~Lbl

Function: This command performs an unconditional jump to a specified location.

Syntax: Goto <label name> ~ Lbl <label name>

Parameters: label name: value (0 to 9), variable (A to Z, *r*, *θ*)

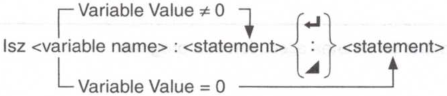
Description:

- This command consists of two parts: Goto *n* (where *n* is a parameter as described above) and Lbl *n* (where *n* is the parameter referenced by Goto *n*). This command causes program execution to jump to the Lbl-statement whose *n* parameter matches that specified by the Goto-statement.
- This command can be used to loop back to the beginning of a program or to jump to any location within the program.
- This command can be used in combination with conditional jumps and count jumps.
- If there is no Lbl-statement whose value matches that specified by the Goto-statement, an error occurs.

Isz

Function: This command is a count jump that increments the value of a control variable by 1, and then jumps if the current value of the variable is zero.

Syntax:



Parameters: variable name: A to Z, *r*, *θ*

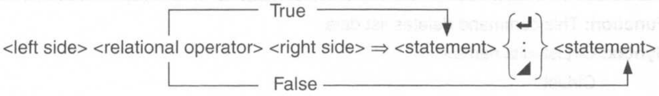
[Example] Isz A : Increments the value assigned to variable A by 1.

Description: This command increments the value of a control variable by 1, and then tests (checks) it. If the current value is non-zero, execution continues with the next statement. If the current value is zero, execution jumps to the statement following the multi-statement command (:), display command (◢), or carriage return (↵).

⇒ (Jump Code)

Function: This code is used to set up conditions for a conditional jump. The jump is executed whenever the conditions are false.

Syntax:



<left side> <relational operator> <right side> ⇒ <statement> {↵ : ◢} <statement>

Parameters:

- left side/right side: variable (A to Z, r, θ), numeric constant, variable expression (such as: A × 2)
- relational operator: =, ≠, >, <, ≥, ≤ (page 8-18)

Description:

- The conditional jump compares the contents of two variables or the results of two expressions, and a decision is made whether or not to execute the jump based on the results of the comparison.
- If the comparison returns a true result, execution continues with the statement following the ⇒ command. If the comparison returns a false result, execution jumps to the statements following the multi-statement command (:), display command (◢), or carriage return (↵).

Menu

Function: Creates a branching menu in a program.

Syntax: Menu "<string (menu name)>", "<string (branch name) 1>", <value or variable 1>, "<string (branch name) 2>" ,<value or variable 2>, ... , "<string (branch name) *n*>", <value or variable *n*>

Parameters: value (0 to 9), variable (A to Z, r, θ)

Description:

- Each "<string (branch name) *n*>" ,<value or variable *n*> part is a branch set, and the entire branch set must be included.
- From two to nine branching sets can be included. An error occurs when there is only one or more than nine branching sets.
- Selecting a branch on the menu while the program is running jumps to the same type of label (Lbl *n*) as the one used in combination with the Goto command. Specifying ""OK", 3" for the ""<string (branch name) *n*>", <value or variable *n*>" part specifies a jump to Lbl 3.

Example: Lbl 2↵

```
Menu "IS IT DONE?", "OK", 1, "EXIT", 2↵
Lbl 1↵
"IT'S DONE !"
```

■ Clear Commands (CLR)

ClrGraph

Function: This command clears the graph screen.

Syntax: ClrGraph ↵

Description: This command clears the graph screen during program execution.

ClrList

Function: This command deletes list data.

Syntax: ClrList <list name>
ClrList

Parameters: list name: 1 to 26, Ans

Description: This command deletes the data in the list specified by "list name". All list data is deleted if nothing is specified for "list name".

ClrMat

Function: This command deletes matrix data.

Syntax: ClrMat <matrix name>
ClrMat

Parameters: matrix name: A to Z, Ans

Description: This command deletes the data in the matrix specified by "matrix name". All matrix data is deleted if nothing is specified for "matrix name".

ClrText

Function: This command clears the text screen.

Syntax: ClrText ↵

Description: This command clears text from the screen during program execution.

■ Display Commands (DISP)

DispF-Tbl, DispR-Tbl **No parameters**

Function: These commands display numeric tables.

Description:

- These commands generate numeric tables during program execution in accordance with conditions defined within the program.
- DispF-Tbl generates a function table, while DispR-Tbl generates a recursion table.

DrawDyna **No parameters**

Function: This command executes a Dynamic Graph draw operation.

Description: This command draws a Dynamic Graph during program execution in accordance with the drawing conditions defined within the program.

DrawFTG-Con, DrawFTG-Plt

No parameters

Function: This command uses values in a generated table to graph a function.

Description:

- This command draws a function graph in accordance with conditions defined within the program.
- DrawFTG-Con produces a connect type graph, while DrawFTG-Plt produces a plot type graph.

DrawGraph

No parameters

Function: This command draws a graph.

Description: This command draws a graph in accordance with the drawing conditions defined within the program.

DrawR-Con, DrawR-Plt

No parameters

Function: These commands graph recursion expressions, with a_n (b_n or c_n) as the vertical axis and n as the horizontal axis.

Description:

- These commands graph recursion expressions in accordance with conditions defined within the program, with a_n (b_n or c_n) as the vertical axis and n as the horizontal axis.
- DrawR-Con produces a connect type graph, while DrawR-Plt produces a plot type graph.

DrawRΣ-Con, DrawRΣ-Plt

No parameters

Function: These commands graph recursion expressions, with Σa_n (Σb_n or Σc_n) as the vertical axis and n as the horizontal axis.

Description:

- These commands graph recursion expressions in accordance with conditions defined within the program, with Σa_n (Σb_n or Σc_n) as the vertical axis and n as the horizontal axis.
- DrawRΣ-Con produces a connect type graph, while DrawRΣ-Plt produces a plot type graph.

DrawStat

Function: This draws a statistical graph.

Syntax: See "Using Statistical Calculations and Graphs in a Program" on page 8-25.

Description: This command draws a statistical graph in accordance with conditions defined within the program.

DrawWeb

Function: This command graphs convergence/divergence of a recursion expression (WEB graph).

Syntax: DrawWeb <recursion type>[, <number of lines>] ↵

Example: DrawWeb a_{n+1} (b_{n+1} or c_{n+1}), 5 ↵

Description:

- This command graphs convergence/divergence of a recursion expression (WEB graph).
- Omitting the number of lines specification automatically specifies the default value 30.

PlotPhase

Function: Graphs a phase plot based on numeric sequences that correspond to the x-axis and y-axis.

Syntax: PlotPhase <x-axis numeric sequence name>, <y-axis numeric sequence name>

Description:

- Only the following commands can be input for each argument to specify the recursion table.

  a_n, b_n, c_n, a_{n+1}, b_{n+1}, c_{n+1}, a_{n+2}, b_{n+2}, c_{n+2}, Σa_n, Σb_n, Σc_n, Σa_{n+1}, Σb_{n+1}, Σc_{n+1}, Σa_{n+2}, Σb_{n+2}, Σc_{n+2}

- A memory ERROR occurs if you specify a numeric sequence name that does not have values stored in the recursion table.

Example: PlotPhase Σb_{n+1}, Σa_{n+1}

Graphs a phase plot using Σb_{n+1} for the x-axis and Σa_{n+1} for the y-axis.

■ Input/Output Commands (I/O)

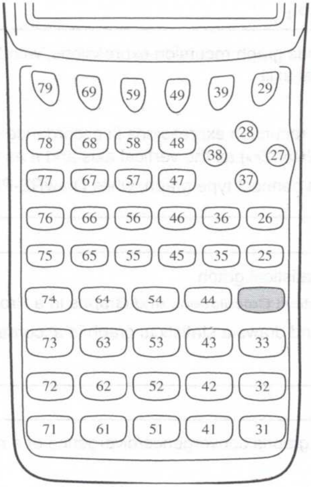
Getkey

Function: This command returns the code that corresponds to the last key pressed.

Syntax: Getkey ↵

Description:

- This command returns the code that corresponds to the last key pressed.


79
69
59
49
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29
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78
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76
66
56
46
36
26
75
65
55
45
35
25
74
64
54
44
73
63
53
43
33
72
62
52
42
32
71
61
51
41
31

- A value of zero is returned if no key was pressed previous to executing this command.
- This command can be used inside of a loop.

Locate

Function: This command displays alpha-numeric characters at a specific location on the text screen.

Syntax: Locate <column number>, <line number>, <value>

Locate <column number>, <line number>, <numeric expression>

Locate <column number>, <line number>, "<string>"

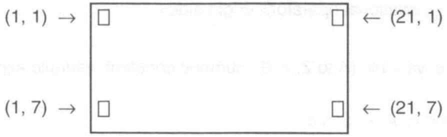
[Example] Locate 1, 1, "AB" ↵

Parameters:

- line number: number from 1 to 7
- column number: number from 1 to 21
- value and numeric expression
- string: character string

Description:

- This command displays values (including variable contents) or text at a specific location on the text screen. If there is a calculation input, that calculation result is displayed.
- The line is designated by a value from 1 to 7, while the column is designated by a value from 1 to 21.



Example: Cls ↵

Locate 7, 1, "CASIO FX"

This program displays the text "CASIO FX" in the center of the screen.

- In some cases, the ClrText command should be executed before running the above program.

Receive(/ Send(

Function: This command receives data from and sends data to a connected device.

Syntax: Receive(<data>) / Send(<data>)

Description:

- This command receives data from and sends data to a connected device.
- The following types of data can be received (sent) by this command.
  - Individual values assigned to variables
  - Matrix data (all values - individual values cannot be specified)
  - List data (all values - individual values cannot be specified)

OpenComport38k / CloseComport38k

Function: Opens and closes the 3-pin COM port (serial).

Description: See the Receive38k/Send38k command below.

Receive38k / Send38k

Function: Executes data send and receive at a data rate of 38 kbps.

Syntax: Send38k <expression>

$$\text{Receive38k}\begin{Bmatrix}\text{<variable name>}\\ \text{<list name>}\end{Bmatrix}$$

Description:

- The OpenComport38k command must be executed before this command is executed.
- The CloseComport38k command must be executed after this command is executed.
- If this command is executed when the communication cable is not connected, program execution will continue without generating an error.

Conditional Jump Relational Operators (REL)

=, ≠, >, <, ≥, ≤

Function: These relational operators are used in combination with the conditional jump command.

Syntax: <left side> <relational operator> <right side>

Parameters:

- left side/right side: variable (A to Z, r, θ), numeric constant, variable expression (such as: A × 2)
- relational operator: =, ≠, >, <, ≥, ≤

Strings

A string is a series of characters enclosed in double quotes. In a program, strings are used to specify display text. A string made up of numbers (like "123") or an expression (like "x–1") cannot be processed as a calculation.

To display a string at a specific location on the screen, use the Locate command (page 8-17).

- To include double quotes (") or a backslash (\) in a string, put a backslash (\) in front of the double quotes (") or backslash (\).

  Example 1: To include Japan: "Tokyo" in a string
  "Japan:\"Tokyo\""

  Example 2: To include main\abc in a string
  "main\\abc"

You can input a backslash from the menu that appears when you press F6(CHAR)F2(SYBL) in the **PRGM** mode, or from the String category of the catalog that appears when you press SHIFT 4(CATALOG).

- You can assign strings to string memory (Str 1 through Str 20). For details about strings, see "String Memory" (page 2-5).
- You can use the "+" command (page 8-20) to connect strings inside of an argument.
- A function or command within a string function (Exp(, StrCmp(, etc.) is treated as a single character. For example, the "sin" function is treated as a single character.

Exp(

Function: Converts a string to an expression, and executes the expression.

Syntax: Exp("<string>"[)]

Exp▶Str(

Function: Converts a graph expression to a string and assigns it to the specified variable.

Syntax: Exp▶Str(<formula>, <string variable name>[)]

Description: A graph expression (Y_n, r, X_t, Y_t, X), recursion formula (a_n, a_{n+1}, a_{n+2}, b_n, b_{n+1}, b_{n+2}, c_n, c_{n+1}, c_{n+2}), or function memory (f_n) can be used as the first argument (<formula>).

StrCmp(

Function: Compares "<string 1>" and "<string 2>" (character code comparison).

Syntax: StrCmp("<string 1>", "<string 2>"[)]

Description: Compares two strings and returns one of the following values.

Returns 0 when "<string 1>" = "<string 2>".

Returns 1 when "<string 1>" > "<string 2>".

Returns –1 when "<string 1>" < "<string 2>".

StrInv(

Function: Inverts the sequence of a string.

Syntax: StrInv("<string>"[)]

StrJoin(

Function: Joins "<string 1>" and "<string 2>".

Syntax: StrJoin("<string 1>", "<string 2>"[)]

Note: The same result also can be achieved using the "+" command (page 8-20).

StrLeft(

Function: Copies a string up to the *n*th character from the left.

Syntax: StrLeft("<string>", *n*[)] (0 ≦ *n* ≦ 9999, *n* is a natural number)

StrLen(

Function: Returns the length of a string (the number of its characters).

Syntax: StrLen("<string>"[)]

StrLwr(

Function: Converts all the characters of a string to lower case.

Syntax: StrLwr("<string>"[)]

StrMid(

Function: Extracts from the n-th to the m-th character of a string.

Syntax: StrMid("<string>", n [,m)]   ($0 \leqq n \leqq 9999$, n is a natural number)

Description: Omitting "m" will extract from the n-th character to the end of the string.

StrRight(

Function: Copies a string up to the nth character from the right.

Syntax: StrRight("<string>", n[)]   ($0 \leqq n \leqq 9999$, n is a natural number)

StrRotate(

Function: Rotates the left side part and right side part of a string at the nth character.

Syntax: StrRotate("<string>", [,n)]   ($-9999 \leqq n \leqq 9999$, n is an integer)

Description: Rotation is to the left when "n" is positive, and to the right when "n" is negative. Omitting "n" uses a default value of +1.

Example: StrRotate("abcde", 2) .... Returns the string "cdeab".

StrShift(

Function: Shifts a string left or right n characters.

Syntax: StrShift("<string>", [,n)]   ($-9999 \leqq n \leqq 9999$, n is an integer)

Description: Shift is to the left when "n" is positive, and to the right when "n" is negative. Omitting "n" uses a default value of +1.

Example: StrShift("abcde", 2) .... Returns the string "cde".

StrSrc(

Function: Searches "<string 1>" starting from the specified point (nth character from beginning of string) to determine if it contains the data specified by "<string 2>". If the data is found, this command returns the location of the first character of "<string 2>", starting from the beginning of "<string 1>".

Syntax: StrSrc("<string 1>", "<string 2>"[,n)]   ($0 \leqq n \leqq 9999$, n is a natural number)

Description: Omitting the start point causes the search to start from the beginning of "<string 1>".

StrUpr(

Function: Converts all the characters of a string to upper case.

Syntax: StrUpr("<string>"[)]

+

Function: Joins "<string 1>" and "<string 2>".

Syntax: "<string 1>"+"<string 2>"

Example: "abc"+"de"→Str 1.......... Assigns "abcde" to Str 1.

Other

RclCapt

Function: Displayed the contents specified by the capture memory number.

Syntax: RclCapt <capture memory number> (capture memory number: 1 to 20)

6. Using Calculator Functions in Programs

Text Display

You can include text in a program by simply enclosing it between double quotation marks. Such text appears on the display during program execution, which means you can add labels to input prompts and results.

Program	**Display**
"CASIO"	CASIO
? → X	?
"X =" ? → X	X = ?

- If the text is followed by a calculation formula, be sure to insert a display command (◢) between the text and calculation.
- Inputting more than 21 characters causes the text to move down to the next line. The screen scrolls automatically if the text exceeds 21 characters.
- You can specify up to 255 bytes of text for a comment.

Using Matrix Row Operations in a Program

These commands let you manipulate the rows of a matrix in a program.

- For this program, enter the **RUN•MAT** mode and then use the Matrix Editor to input the matrix, and then enter the **PRGM** mode to input the program.

• To swap the contents of two rows (Swap)

Example 1 **To swap the values of Row 2 and Row 3 in the following matrix:**

$$\textbf{Matrix A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix}$$

The following is the syntax to use for this program.

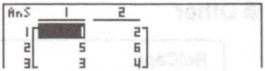
Swap A, 2, 3↵

Rows to be swapped

Matrix name

Mat A

Executing this program produces the following result.



```
AnS    1      2
  1[      1      2]
  2[      5      6]
  3[      3      4]
```

- **To calculate a scalar multiplication (∗Row)**

Example 2 **To calculate the product of Row 2 of the matrix in Example 1 and the scalar 4**

The following is the syntax to use for this program.

∗Row 4, A, 2↵

Row

Matrix name

Multiplier

Mat A

- **To calculate a scalar multiplication and add the results to another row (∗Row+)**

Example 3 **To calculate the product of Row 2 of the matrix in Example 1 and the scalar 4, then add the result to row 3**

The following is the syntax to use for this program.

∗Row+ 4, A, 2, 3↵

Rows to be added

Row for which scalar multiplication is to be calculated

Matrix name

Multiplier

Mat A

- **To add two rows (Row+)**

Example 4 **To add Row 2 to Row 3 of the matrix in Example 1**

The following is the syntax to use for this program.

Row+ A, 2, 3↵

Row number to be added to

Row number to be added

Matrix name

Mat A

Using Graph Functions in a Program

You can incorporate graph functions into a program to draw complex graphs and to overlay graphs on top of each other. The following shows various types of syntax you need to use when programming with graph functions.

- V-Window View Window –5, 5, 1, –5, 5, 1↵
- Graph function input Y = Type↵ ....Specifies graph type.

"X^2 – 3" → Y1[*1]↵

- Graph draw operation DrawGraph↵

*1 Input this Y1 with VARS F4(GRPH) F1(Y) 1 (displayed as **Y1**). A Syntax ERROR will occur if you input "Y" with the calculator keys.

• Syntax of other graphing functions

• V-Window	View Window <Xmin>, <Xmax>, <Xscale>, <Ymin>, <Ymax>, <Yscale>, <Tθ min>,<Tθ max>, <Tθ pitch>	
	StoV-Win <area of V-Win>	area: 1 to 6
	RclV-Win <area of V-Win>	area: 1 to 6
• Zoom	Factor <X factor>, <Y factor>	
	ZoomAuto	Non-parameter
• Pict	StoPict <area of picture> numeric expression	area: 1 to 6
	RclPict <area of picture> numeric expression	area: 1 to 6
• Sketch	PlotOn <X-coordinate>, <Y-coordinate>	
	PlotOff <X-coordinate>, <Y-coordinate>	
	PlotChg <X-coordinate>, <Y-coordinate>	
	PxlOn <line number>, <column number>	
	PxlOff <line number>, <column number>	
	PxlChg <line number>, <column number>	
	PxlTest <line number>, <column number>	
	Text <line number>, <column number>, "<text>"	
	Text <line number>, <column number>, <expression>	
	SketchThick <Sketch or Graph statement>	
	SketchBroken <Sketch or Graph statement>	
	SketchDot <Sketch or Graph statement>	
	SketchNormal <Sketch or Graph statement>	
	Tangent <function>, <X-coordinate>	
	Normal <function>, <X-coordinate>	
	Inverse <function>	
	Line	
	F-Line <X-coordinate 1>, <Y-coordinate 1>, <X-coordinate 2>, <Y-coordinate 2>	
	Circle <center point X-coordinate>, <center point Y-coordinate>, <radius R value>	
	Vertical <X-coordinate>	
	Horizontal <Y-coordinate>	

■ Using Dynamic Graph Functions in a Program

Using Dynamic Graph functions in a program makes it possible to perform repeated Dynamic Graph operations. The following shows how to specify the Dynamic Graph range inside a program.

- Dynamic Graph range

  1 → D Start↵

  5 → D End↵

  1 → D pitch↵

■ Using Table & Graph Functions in a Program

Table & Graph functions in a program can generate numeric tables and perform graphing operations. The following shows various types of syntax you need to use when programming with Table & Graph functions.

- Table range setting

  1 → F Start↵

  5 → F End↵

  1 → F pitch↵

- Numeric table generation

  DispF-Tbl↵

- Graph draw operation

  Connect type: DrawFTG-Con↵

  Plot type: DrawFTG-Plt↵

■ Using Recursion Table & Graph Functions in a Program

Incorporating Recursion Table & Graph functions in a program lets you generate numeric tables and perform graphing operations. The following shows various types of syntax you need to use when programming with Recursion Table & Graph functions.

- Recursion formula input

  a_{n+1} Type↵ .... Specifies recursion type.

  "$3a_n + 2$" → a_{n+1}↵

  "$4b_n + 6$" → b_{n+1}↵

- Table range setting

  1 → R Start↵

  5 → R End↵

  1 → a_0↵

  2 → b_0↵

  1 → a_n Start↵

  3 → b_n Start↵

- Numeric table generation

  DispR-Tbl↵

- Graph draw operation

  Connect type: DrawR-Con↵, DrawRΣ-Con↵

  Plot type: DrawR-Plt↵, DrawRΣ-Plt↵

- Statistical convergence/divergence graph (WEB graph)

  DrawWeb a_{n+1}, 10↵

■ Using List Sort Functions in a Program

These functions let you sort data in lists into ascending or descending order.

- Ascending order

  ① ②
  SortA (List 1, List 2, List 3)
  Lists to be sorted (up to six can be specified)

  ① F4 F3 F1 ② OPTN F1 F1

- Descending order

③
SortD (List 1, List 2, List 3)
Lists to be sorted (up to six can be specified)

③ F4 F3 F2

■ Using Statistical Calculations and Graphs in a Program

Including statistical calculations and graphing operations in a program lets you calculate and graph statistical data.

• To set conditions and draw a statistical graph

Following a StatGraph command ("S-Gph1", "S-Gph2", or "S-Gph3"), you must specify the following graph conditions:

- Graph draw/non-draw status (DrawOn/DrawOff)
- Graph Type
- x-axis data location (list name)
- y-axis data location (list name)
- Frequency data location (list name)
- Mark Type
- Pie graph display setting (% or Data)
- Pie graph percentage data storage list specification (None or list name)
- First bar graph data (list name)
- Second and third bar graph data (list name)
- Bar graph orientation (Length or Horizontal)

The graph conditions that are required depends on the graph type. See "Changing Graph Parameters" (page 6-1).

- The following is a typical graph condition specification for a scatter diagram or xyLine graph.

  S-Gph1 DrawOn, Scatter, List 1, List 2, 1, Square ↵

  In the case of an xy line graph, replace "Scatter" in the above specification with "xyLine".

- The following is a typical graph condition specification for a normal probability plot.

  S-Gph1 DrawOn, NPPlot, List 1, Square ↵

- The following is a typical graph condition specification for a single-variable graph.

  S-Gph1 DrawOn, Hist, List 1, List 2 ↵

  The same format can be used for the following types of graphs, by simply replacing "Hist" in the above specification with the applicable graph type.

Histogram	Hist	Normal Distribution	N-Dist
Median Box	MedBox*1	Broken Line	Broken

*1 Outliers:On
S-Gph1 DrawOn, MedBox, List 1, 1, 1

Outliers:Off
S-Gph1 DrawOn, MedBox, List 1, 1, 0

- The following is a typical graph condition specification for a regression graph.

```
S-Gph1 DrawOn, Linear, List 1, List 2, List 3 ↵
```

The same format can be used for the following types of graphs, by simply replacing "Linear" in the above specification with the applicable graph type.

Linear Regression	Linear	Logarithmic Regression	Log
Med-Med	Med-Med	Exponential Regression	ExpReg(a·e^bx)
Quadratic Regression	Quad		ExpReg(a·b^x)
Cubic Regression	Cubic	Power Regression	Power
Quartic Regression	Quart		

- The following is a typical graph condition specification for a sinusoidal regression graph.

```
S-Gph1 DrawOn, Sinusoidal, List 1, List 2 ↵
```

- The following is a typical graph condition specification for a logistic regression graph.

```
S-Gph1 DrawOn, Logistic, List 1, List 2 ↵
```

- The following is a typical graph condition specification for a pie graph.

```
S-Gph1 DrawOn, Pie, List 1, %, None ↵
```

- The following is a typical graph condition specification for a bar graph.

```
S-Gph1 DrawOn, Bar, List 1, None, None, StickLength ↵
```

- To draw a statistical graph, insert the "DrawStat" command following the graph condition specification line.

```
ClrGraph
S-Wind Auto
{1, 2, 3} → List 1
{1, 2, 3} → List 2
S-Gph1 DrawOn, Scatter, List 1, List 2, 1, Square ↵
DrawStat
```

■ Using Distribution Graphs in a Program

Special commands are used to draw distribution graphs in a program.

• To draw a normal cumulative distribution graph

①DrawDistNorm <Lower>, <Upper> [,σ, μ]

Population mean[*1]

Population standard deviation[*1]

Data upper limit

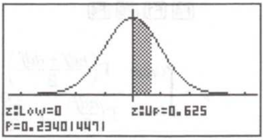
Data lower limit

① F4 F1 F5 F1

[*1] This can be omitted. Omitting these items performs the calculation using $\sigma = 1$ and $\mu = 0$.

$$p = \frac{1}{\sqrt{2\pi}\sigma}\int_{Lower}^{Upper} e^{-\frac{(x-\mu)^2}{2\sigma^2}}\,dx \qquad \text{ZLow} = \frac{Lower - \mu}{\sigma} \qquad \text{ZUp} = \frac{Upper - \mu}{\sigma}$$

- Executing DrawDistNorm performs the above calculation in accordance with the specified conditions and draws the graph. At this time the ZLow ≦ x ≦ ZUp region on the graph is filled in.



```
z:Low=0          z:Up=0.625
p=0.234014471
```

- At the same time, the p, ZLow, and ZUp calculation result values are assigned respectively to variables p, ZLow, and ZUp, and p is assigned to Ans.

• To draw a Student-t cumulative distribution graph

①DrawDistT <Lower>, <Upper>, <*df*>

Degree of freedom
Data upper limit
Data lower limit

① F4 F1 F5 F2

$$p = \int_{Lower}^{Upper} \frac{\Gamma\left(\frac{df+1}{2}\right)}{\Gamma\left(\frac{df}{2}\right)} \times \frac{\left(1 + \frac{x^2}{df}\right)^{-\frac{df+1}{2}}}{\sqrt{\pi \times df}}\, dx \qquad \text{tLow} = Lower \qquad \text{tUp} = Upper$$

- Executing DrawDistT performs the above calculation in accordance with the specified conditions and draws the graph. At this time the Lower ≦ x ≦ Upper region on the graph is filled in.
- At the same time, the p calculation result value and the Lower and Upper input values are assigned respectively to variables p, tLow, and tUp, and p is assigned to Ans.

• To draw a χ^2 cumulative distribution graph

①DrawDistChi <Lower>, <Upper>, <*df*>

Degree of freedom
Data upper limit
Data lower limit

① F4 F1 F5 F3

$$p = \int_{Lower}^{Upper} \frac{1}{\Gamma\left(\frac{df}{2}\right)} \times \left(\frac{1}{2}\right)^{\frac{df}{2}} \times x^{\left(\frac{df}{2}-1\right)} \times e^{-\frac{x}{2}}\, dx$$

- Executing DrawDistChi performs the above calculation in accordance with the specified conditions and draws the graph. At this time the Lower ≦ x ≦ Upper region on the graph is filled in.
- At the same time, calculation result p is assigned to variables p and Ans.

• To draw an F cumulative distribution graph

①DrawDistF <Lower>, <Upper>, <*ndf*>, <*ddf*>

Degrees of freedom of denominator
Degrees of freedom of numerator
Data upper limit
Data lower limit

① F4 F1 F5 F4

$$p = \int_{Lower}^{Upper} \frac{\Gamma\left(\frac{ndf+ddf}{2}\right)}{\Gamma\left(\frac{ndf}{2}\right)\times\Gamma\left(\frac{ddf}{2}\right)} \times \left(\frac{ndf}{ddf}\right)^{\frac{ndf}{2}} \times x^{\left(\frac{ndf}{2}-1\right)} \times \left(1+\frac{ndf\times x}{ddf}\right)^{-\frac{ndf+ddf}{2}} dx$$

- Executing DrawDistF performs the above calculation in accordance with the specified conditions and draws the graph. At this time the Lower ≦ x ≦ Upper region on the graph is filled in.
- At the same time, calculation result p is assigned to variables p and Ans.

■ Performing Statistical Calculations in a Program

- Single-variable statistical calculation

①1-Variable List1, List 2

List 2 — *Frequency data (Frequency)*

List1 — *x-axis data (XList)*

① F4 F1 F6 F1

- Paired-variable statistical calculation

①2-Variable List 1, List 2, List 3

List 3 — *Frequency data (Frequency)*

List 2 — *y-axis data (YList)*

List 1 — *x-axis data (XList)*

① F4 F1 F6 F2

- Regression statistical calculation

①LinearReg(ax+b) List 1, List 2, List 3

LinearReg(ax+b) — *Calculation type**

List 3 — *Frequency data (Frequency)*

List 2 — *y-axis data (YList)*

List 1 — *x-axis data (XList)*

① F4 F1 F6 F6 F1 F1

* Any one of the following can be specified as the calculation type.

LinearReg(ax+b)......linear regression ($ax+b$ type)
LinearReg(a+bx)......linear regression ($a+bx$ type)
Med-MedLine ....Med-Med calculation
QuadReg ....quadratic regression
CubicReg.................cubic regression
QuartReg.................quartic regression
LogReg ....logarithmic regression
ExpReg(a·e^bx)........exponential regression ($a{\cdot}e^{bx}$ type)
ExpReg(a·b^x).........exponential regression ($a{\cdot}b^x$ type)
PowerReg ....power regression

- Sinusoidal regression statistical calculation

  SinReg List 1, List 2

  y-axis data (YList)

  x-axis data (XList)

- Logistic regression statistical calculation

  LogisticReg List 1, List 2

  y-axis data (YList)

  x-axis data (XList)

Performing Distribution Calculations in a Program

- The following values are substituted whenever any of the values enclosed in brackets ([ ]) are omitted.

  σ=1, μ=0, tail=L (Left)

- For the calculation formula of each probability density function, see "Statistic Formula" (page 6-53).

• Normal Distribution

NormPD(: Returns the normal probability density (p value) for the specified data.

Syntax: NormPD(x[, σ, μ)]

- A single value or a list can be specified for x. Calculation result p is assigned to variables p and Ans (ListAns when x is a list).

NormCD(: Returns the normal cumulative distribution (p value) for the specified data.

Syntax: NormCD(Lower, Upper[, σ, μ)]

- Single values or lists can be specified for Lower and Upper. Calculation results p, ZLow, and ZUp are assigned respectively to variables p, ZLow, and ZUp. Calculation result p also is assigned to Ans (ListAns when Lower and Upper are lists).

InvNormCD(: Returns the inverse normal cumulative distribution (lower and/or upper value(s)) for the specified p value.

Syntax: InvNormCD(["L(or –1) or R(or 1) or C(or 0)",]p[,σ, μ])

tail (Left, Right, Central)

- A single value or a list can be specified for p. Calculation results are output in accordance with the tail setting as described below.

  tail = Left

  The Upper value is assigned to variables x1InvN and Ans (ListAns when p is a list).

  tail = Right

  The Lower value is assigned to variables x1InvN and Ans (ListAns when p is a list).

  tail = Central

  The Lower and Upper values are assigned respectively to variables x1InvN and x2InvN. Lower only is assigned to Ans (ListAns when p is a list).

• Student-*t* Distribution

tPD(: Returns the Student-*t* probability density (*p* value) for the specified data.

Syntax: tPD(x, *df* [)]

- A single value or a list can be specified for x. Calculation result p is assigned to variables p and Ans (ListAns when x is a list).

tCD(: Returns the Student-*t* cumulative distribution (*p* value) for the specified data.

Syntax: tCD(Lower,Upper,*df* [)]

- Single values or lists can be specified for Lower and Upper. Calculation results p, tLow, and tUp are assigned respectively to variables p, tLow, and tUp. Calculation result p also is assigned to Ans (ListAns when Lower and Upper are lists).

InvTCD(: Returns the inverse Student-*t* cumulative distribution (Lower value) for the specified p value.

Syntax: InvTCD(p,*df* [)]

- A single value or a list can be specified for p. The Lower value is assigned to the xInv and Ans variables (ListAns when p is a list).

• χ^2 Distribution

ChiPD(: Returns the χ^2 probability density (*p* value) for the specified data.

Syntax: ChiPD(x,*df* [)]

- A single value or a list can be specified for x. Calculation result p is assigned to variables p and Ans (ListAns when x is a list).

ChiCD(: Returns the χ^2 cumulative distribution (*p* value) for the specified data.

Syntax: ChiCD(Lower,Upper,*df* [)]

- Single values or lists can be specified for Lower and Upper. Calculation result p is assigned to variables p and Ans (ListAns when Lower and Upper are lists).

InvChiCD(: Returns the inverse χ^2 cumulative distribution (Lower value) for the specified p value.

Syntax: InvChiCD(p,*df* [)]

- A single value or a list can be specified for p. The Lower value is assigned to the xInv and Ans variables (ListAns when p is a list).

• *F* Distribution

FPD(: Returns the *F* probability density (*p* value) for the specified data.

Syntax: FPD(x,*ndf*,*ddf* [)]

- A single value or a list can be specified for x. Calculation result p is assigned to variables p and Ans (ListAns when x is a list).

FCD(: Returns the *F* cumulative distribution (*p* value) for the specified data.

Syntax: FCD(Lower,Upper,*ndf*,*ddf* [)]

- Single values or lists can be specified for Lower and Upper. Calculation result p is assigned to variables p and Ans (ListAns when Lower and Upper are lists).

InvFCD(: Returns the inverse F cumulative distribution (Lower value) for the specified data.

Syntax: InvFCD(p,ndf,ddf [)]

- A single value or a list can be specified for p. The Lower value is assigned to the xInv and Ans variables (ListAns when p is a list).

• Binomial Distribution

BinomialPD(: Returns the binomial probability (p value) for the specified data.

Syntax: BinomialPD([x,]n,P[)]

- A single value or a list can be specified for x. Calculation result p is assigned to variables p and Ans (ListAns when x is a list).

BinomialCD(: Returns the binomial cumulative distribution (p value) for the specified data.

Syntax: BinomialCD([X,]n,P[)]

- A single value or a list can be specified for each X. Calculation result p is assigned to variables p and Ans (ListAns when X is omitted or is a list).

InvBinomialCD(: Returns the inverse binomial cumulative distribution for the specified data.

Syntax: InvBinomialCD(p,n,P[)]

- A single value or a list can be specified for p. The calculation result X value is assigned to the xInv and Ans variables (ListAns when p is a list).

• Poisson Distribution

PoissonPD(: Returns the Poisson probability (p value) for the specified data.

Syntax: PoissonPD(x, μ[)]

- A single value or a list can be specified for x. Calculation result p is assigned to variables p and Ans (ListAns when x is a list).

PoissonCD(: Returns the Poisson cumulative distribution (p value) for the specified data.

Syntax: PoissonCD(X,μ[)]

- A single value or a list can be specified for each X. Calculation result p is assigned to variables p and Ans (ListAns when X is a list).

InvPoissonCD(: Returns the inverse Poisson cumulative distribution for the specified data.

Syntax: InvPoissonCD(p,μ[)]

- A single value or a list can be specified for p. The calculation result X value is assigned to the xInv and Ans variables (ListAns when p is a list).

• Geometric Distribution

GeoPD(: Returns the geometric probability (p value) for the specified data.

Syntax: GeoPD(x, P[)]

- A single value or a list can be specified for x. Calculation result p is assigned to variables p and Ans (ListAns when x is a list).

GeoCD(: Returns the geometric cumulative distribution (p value) for the specified data.

Syntax: GeoCD(X,P[)]

- A single value or a list can be specified for each X. Calculation result p is assigned to variables p and Ans (ListAns when X is a list).

InvGeoCD(: Returns the inverse geometric cumulative distribution for the specified data.

Syntax: InvGeoCD(p,P[)]

- A single value or a list can be specified for p. The calculation result X value is assigned to the xInv and Ans variables (ListAns when p is a list).

• Hypergeometric Distribution

HypergeoPD(: Returns the hypergeometric probability (p value) for the specified data.

Syntax: HypergeoPD(x, n, M, N[)]

- A single value or a list can be specified for x. Calculation result p is assigned to variables p and Ans (ListAns when x is a list).

HypergeoCD(: Returns the hypergeometric cumulative distribution (p value) for the specified data.

Syntax: HypergeoCD(X, n, M, N[)]

- A single value or a list can be specified for each X. Calculation result p is assigned to variables p and Ans (ListAns when X is a list).

InvHypergeoCD(: Returns the inverse hypergeometric cumulative distribution for the specified data.

Syntax: InvHypergeoCD(p, n, M, N[)]

- A single value or a list can be specified for p. The calculation result X value is assigned to the xInv and Ans variables (ListAns when p is a list).

■ Using the TEST Command to Execute a Command in a Program

- The following are the specifications ranges for the "μ condition" argument of the command.

  "<" or –1 when $\mu < \mu_0$
  "≠" or 0 when $\mu \neq \mu_0$
  ">" or 1 when $\mu > \mu_0$

  The above also apply for the "ρ condition" and "β&ρ condition" specification methods.
- For explanations of arguments that are not covered in detail here, see "Tests" (page 6-22) and "Input and Output Terms of Tests, Confidence Interval, and Distribution" (page 6-50).
- For the calculation formula of each command, see "Statistic Formula" (page 6-53).

• *Z* Test

OneSample*Z*Test:	Executes 1-sample Z-test calculation.
Syntax:	OneSample*Z*Test "μ condition", μ_0, σ, $\bar{x}$, n
Output Values:	Z, p, $\bar{x}$, n are assigned respectively to variables z, p, $\bar{x}$, n and to ListAns elements 1 through 4.

Syntax: OneSample$Z$Test "μ condition", μ_0, σ, List[, Freq]

Output Values: Z, p, $\bar{x}$, sx, n are assigned respectively to variables z, p, $\bar{x}$, sx, n and to ListAns elements 1 through 5.

TwoSample$Z$Test: Executes 2-sample Z-test calculation.

Syntax: TwoSample$Z$Test "μ_1 condition", σ_1, σ_2, $\bar{x}_1$, n_1, $\bar{x}_2$, n_2

Output Values: Z, p, $\bar{x}_1$, $\bar{x}_2$, n_1, n_2 are assigned respectively to variables z, p, $\bar{x}_1$, $\bar{x}_2$, n_1, n_2 and to ListAns elements 1 through 6.

Syntax: TwoSample$Z$Test "μ_1 condition", σ_1, σ_2, List1, List2[, Freq1 [, Freq2]]

Output Values: Z, p, $\bar{x}_1$, $\bar{x}_2$, sx_1, sx_2, n_1, n_2 are assigned respectively to variables z, p, $\bar{x}_1$, $\bar{x}_2$, sx_1, sx_2, n_1, n_2 and to ListAns elements 1 through 8.

OneProp$Z$Test: Executes 1-proportion Z-test calculation.

Syntax: OneProp$Z$Test "p condition", p_0, x, n

Output Values: Z, p, $\hat{p}$, n are assigned respectively to variables z, p, $\hat{p}$, n and to ListAns elements 1 through 4.

TwoProp$Z$Test: Executes 2-proportion Z-test calculation.

Syntax: TwoProp$Z$Test "p_1 condition", x_1, n_1, x_2, n_2

Output Values: Z, p, $\hat{p}_1$, $\hat{p}_2$, $\hat{p}$, n_1, n_2 are assigned respectively to variables z, p, $\hat{p}_1$, $\hat{p}_2$, $\hat{p}$, n_1, n_2 and to ListAns elements 1 through 7.

• t Test

OneSampleTTest: Executes 1-sample t-test calculation.

Syntax: OneSampleTTest "μ condition", μ_0, $\bar{x}$, sx, n
OneSampleTTest "μ condition", μ_0, List[, Freq]

Output Values: t, p, $\bar{x}$, sx, n are assigned respectively to the variables with the same names and to ListAns elements 1 through 5.

TwoSampleTTest: Executes 2-sample t-test calculation.

Syntax : TwoSampleTTest "μ_1 condition", $\bar{x}_1$, sx_1, n_1, $\bar{x}_2$, sx_2, n_2[,Pooled condition]
TwoSampleTTest "μ_1 condition", List1, List2, [, Freq1[, Freq2[, Pooled condition]]]

Output Values: When Pooled condition = 0, t, p, df, $\bar{x}_1$ $\bar{x}_2$, sx_1, sx_2, n_1, n_2 are assigned respectively to the variables with the same names and to ListAns elements 1 through 9.
When Pooled condition = 1, t, p, df, $\bar{x}_1$, $\bar{x}_2$, sx_1, sx_2, sp, n_1, n_2 are assigned respectively to the variables with the same names and to ListAns elements 1 through 10.

Note: Specify 0 when you want to turn off the Pooled condition and 1 when you want to turn it on. Omitting the input is treated as Pooled condition off.

LinRegTTest: Executes linear regression t-test calculation.

Syntax: LinRegTTest "β&ρ condition", XList, YList[, Freq]

Output Values: t, p, df, a, b, s, r, r^2 are assigned respectively to the variables with the same names and to ListAns elements 1 through 8.

• χ^2 Test

ChiGOFTest: Executes a chi-square goodness of fit test.

Syntax: ChiGOFTest List1, List2, df, List3
(List 1 is the Observed list, List 2 is the Expected list, and List 3 is the CNTRB list.)

Output Values: χ^2, p, df are assigned respectively to the variables with the same names and to ListAns elements 1 through 3. The CNTRB list is stored in List 3.

ChiTest: Executes a chi-square test.

Syntax: ChiTest MatA, MatB
(MatA is the Observed matrix and MatB is the Expected matrix.)

Output Values: χ^2, p, df are assigned respectively to the variables with the same names and to ListAns elements 1 through 3. The Expected matrix is assigned to MatB.

• F Test

Two Sample*F*Test: Executes 2-sample F-test calculation.

Syntax: TwoSample*F*Test "σ_1 condition", s_{x1}, n_1, s_{x2}, n_2

Output Values: F, p, s_{x1}, s_{x2}, n_1, n_2 are assigned respectively to the variables with the same names and to ListAns elements 1 through 6.

Syntax: TwoSample*F*Test "σ_1 condition", List1, List2, [, Freq1 [, Freq2]]

Output Values: F, p, $\bar{x}_1$, $\bar{x}_2$, s_{x1}, s_{x2}, n_1, n_2 are assigned respectively to the variables with the same names and to ListAns elements 1 through 8.

• ANOVA

OneWayANOVA: Executes one-factor ANOVA analysis of variance.

Syntax: OneWayANOVA List1, List2
(List1 is Factor list (A) and List2 is the Dependent list.)

Output Values: Adf, Ass, Ams, AF, Ap, ERRdf, ERRss, ERRms are assigned respectively to variables Adf, SSa, MSa, Fa, pa, Edf, SSe, MSe.

Also, output values are assigned to MatAns as shown below.

$$\text{MatAns} = \begin{bmatrix} Adf & Ass & Ams & AF & Ap \\ ERRdf & ERRss & ERRms & 0 & 0 \end{bmatrix}$$

TwoWayANOVA: Executes two-factor ANOVA analysis of variance.

Syntax: TwoWayANOVA List1, List2, List3 (List1 is Factor list (A), List2 is Factor list (B), and List3 is the Dependent list.)

Output Values: Adf, Ass, Ams, AF, Ap, Bdf, Bss, Bms, BF, Bp, ABdf, ABss, ABms, ABF, ABp, ERRdf, ERRss, ERRms are assigned respectively to variables Adf, SSa, MSa, Fa, pa, Bdf, SSb, MSb, Fb, pb, ABdf, SSab, MSab, Fab, pab, Edf, SSe, MSe.

Also, output values are assigned to MatAns as shown below.

$$\text{MatAns} = \begin{bmatrix} Adf & Ass & Ams & AF & Ap \\ Bdf & Bss & Bms & BF & Bp \\ ABdf & ABss & ABms & ABF & ABp \\ ERRdf & ERRss & ERRms & 0 & 0 \end{bmatrix}$$

■ Performing Financial Calculations in a Program

• Setup Commands

- Date Mode Setting for Financial Calculations

DateMode365....... 365 days
DateMode360....... 360 days

- Payment Period Setting

PmtBgn................. Start of period
PmtEnd................. End of period

- Bond Calculation Payment Periods

PeriodsAnnual ...... Annual
PeriodsSemi .... Semiannual

• Financial Calculation Commands

For the meaning of each argument, see "Chapter 7 Financial Calculation (TVM)".

• Simple Interest

Smpl_SI: Returns the interest based on simple interest calculation.
Syntax: Smpl_SI(n, I%, PV)

Smpl_SFV: Returns the total of principal and interest based on simple interest calculation.
Syntax: Smpl_SFV(n, I%, PV)

• Compound Interest

Note:

- P/Y and C/Y can be omitted for all compound interest calculations. When they are omitted, calculations are performed using P/Y=12 and C/Y=12.
- If you perform a calculation that uses a compound interest function (Cmpd_n(, Cmpd_I%(, Cmpd_PV(, Cmpd_PMT(, Cmpd_FV(), the argument(s) you input and the calculation results will be saved to the applicable variables (n, I%, PV, etc.). If you perform a calculation that uses any other type of financial calculation function, the argument and calculation results are not assigned to variables.

Cmpd_n: Returns the number of compound periods.
Syntax: Cmpd_n(I%, PV, PMT, FV, P/Y, C/Y)

Cmpd_I%: Returns the annual interest.
Syntax: Cmpd_I%(n, PV, PMT, FV, P/Y, C/Y)

Cmpd_PV: Returns the present value (loan amount for installment payments, principal for savings).
Syntax: Cmpd_PV(n, I%, PMT, FV, P/Y, C/Y)

Cmpd_PMT: Returns equal input/output values (payment amounts for installment payments, deposit amounts for savings) for a fixed period.
Syntax: Cmpd_PMT(n, I%, PV, FV, P/Y, C/Y)

Cmpd_FV: Returns the final input/output amount or total principal and interest.

Syntax: Cmpd_FV(*n*, *I*%, PV, PMT, P/Y, C/Y)

• Cash Flow (Investment Appraisal)

Cash_NPV: Returns the net present value.

Syntax: Cash_NPV(*I*%, Csh)

Cash_IRR: Returns the internal rate of return.

Syntax: Cash_IRR(Csh)

Cash_PBP: Returns the payback period.

Syntax: Cash_PBP(*I*%, Csh)

Cash_NFV: Returns the net future value.

Syntax: Cash_NFV(*I*%, Csh)

• Amortization

Amt_BAL: Returns the remaining principal balance following payment PM2.

Syntax: Amt_BAL(PM1, PM2, *I*%, PV, PMT, P/Y, C/Y)

Amt_INT: Returns the interest paid for payment PM1.

Syntax: Amt_INT(PM1, PM2, *I*%, PV, PMT, P/Y, C/Y)

Amt_PRN: Returns the principal and interest paid for payment PM1.

Syntax: Amt_PRN(PM1, PM2, *I*%, PV, PMT, P/Y, C/Y)

Amt_ΣINT: Returns the total principal and interest paid from payment PM1 to PM2.

Syntax: Amt_ΣINT(PM1, PM2, *I*%, PV, PMT, P/Y, C/Y)

Amt_ΣPRN: Returns the total principal paid from payment PM1 to PM2.

Syntax: Amt_ΣPRN(PM1, PM2, *I*%, PV, PMT, P/Y, C/Y)

• Interest Rate Conversion

Cnvt_EFF: Returns the interest rate converted from the nominal interest rate to the effective interest rate.

Syntax: Cnvt_EFF(*n*, *I*%)

Cnvt_APR: Returns the interest rate converted from the effective interest rate to the nominal interest rate.

Syntax: Cnvt_APR(*n*, *I*%)

• Cost, Selling Price, Margin Calculations

Cost: Returns the cost based on a specified selling price and margin.

Syntax: Cost(Sell, Margin)

Sell: Returns the selling price based on a specified cost and margin.

Syntax: Sell(Cost, Margin)

Margin: Returns the margin based on a specified cost and selling price.

Syntax: Margin(Cost, Sell)

- **Day/Date Calculations**

Days_Prd: Returns the number of days from a specified d1 to specified d2.

Syntax: Days_Prd(MM1, DD1, YYYY1, MM2, DD2, YYYY2)

- **Bond Calculations**

Bond_PRC: Returns in list form bond prices based on specified conditions.

Syntax: Bond_PRC(MM1, DD1, YYYY1, MM2, DD2, YYYY2, RDV, CPN, YLD) = {PRC, INT, CST}

Bond_YLD: Returns the yield based on specified conditions.

Syntax: Bond_YLD(MM1, DD1, YYYY1, MM2, DD2, YYYY2, RDV, CPN, PRC)

7. PRGM Mode Command List

Not all of the commands listed below are available on all models covered by this manual.

RUN Program

F4 (MENU) key

Level 1	Level 2	Level 3	Command
STAT	DRAW	On	DrawOn
		Off	DrawOff
	GRPH	GPH1	S-Gph1_
		GPH2	S-Gph2_
		GPH3	S-Gph3_
		Scat	Scatter
		xy	xyLine
		Hist	Hist
		Box	MedBox
		Bar	Bar
		N-Dis	N-Dist
		Brkn	Broken
		X	Linear
		Med	Med-Med
		X^2	Quad
		X^3	Cubic
		X^4	Quart
		Log	Log
			*1
		Pwr	Power
		Sin	Sinusoidal
		NPP	NPPlot
		Lgst	Logistic
		Pie	Pie
	List		List_
	TYPE		*2
	DIST	DrwN	DrawDistNorm_
		Drwt	DrawDistT_
		DrwC	DrawDistChi_
		DrwF	DrawDistF_
	CALC	1VAR	1-Variable_
		2VAR	2-Variable_
			*3
		Med	Med-MedLine_
		X^2	QuadReg_
		X^3	CubicReg_
		X^4	QuartReg_
		Log	LogReg_
			*4
		Pwr	PowerReg_
		Sin	SinReg_
		Lgst	LogisticReg_
MAT	Swap		Swap_
	×Rw		*Row_
	×Rw+		*Row+_
	Rw+		Row+_
LIST	Srt-A		SortA(
	Srt-D		SortD(
GRPH	SEL	On	G_SelOn_
		Off	G_SelOff_
	TYPE	Y=	Y=Type
		r=	r=Type
		Parm	ParamType
		X=	X=Type
		Y>	Y>Type
		Y<	Y<Type
		Y≥	Y≥Type
		Y≤	Y≤Type
		X>	X>Type
		X<	X<Type
		X≥	X≥Type
		X≤	X≤Type
	STYL	—	NormalG_
		—	ThickG_
		·····	BrokenThickG_
		······	DotG_
	GMEM	Sto	StoGMEM_
		Rcl	RclGMEM_
DYNA	On		D_SelOn_
	Off		D_SelOff_
	Var		D_Var_
	TYPE	Y=	Y=Type
		r=	r=Type
		Parm	ParamType
TABL	On		T_SelOn_
	Off		T_SelOff_
	TYPE	Y=	Y=Type
		r=	r=Type
		Parm	ParamType
	STYL	—	NormalG_
		—	ThickG_
		·····	BrokenThickG_
		······	DotG_
RECR	SEL+S	On	R_SelOn_
		Off	R_SelOff_
		—	NormalG_
		—	ThickG_
		·····	BrokenThickG_
		······	DotG_
	TYPE	a_n	a_nType
		a_{n+1}	a_{n+1}Type
		a_{n+2}	a_{n+2}Type
	n.a_n··	n	n
		a_n	a_n
		a_{n+1}	a_{n+1}
		a_{n+2}	a_{n+2}
		b_n	b_n
		b_{n+1}	b_{n+1}
		b_{n+2}	b_{n+2}
		c_n	c_n
		c_{n+1}	c_{n+1}
		c_{n+2}	c_{n+2}
		Σa_n	Σa_n
		Σa_{n+1}	Σa_{n+1}
		Σa_{n+2}	Σa_{n+2}
		Σb_n	Σb_n
		Σb_{n+1}	Σb_{n+1}
		Σb_{n+2}	Σb_{n+2}
		Σc_n	Σc_n
		Σc_{n+1}	Σc_{n+1}
		Σc_{n+2}	Σc_{n+2}

	RANG	a0	Sel_a0
		a1	Sel_a1

OPTN key

Level 1	Level 2	Level 3	Command
LIST	List		List_
	L→M		List→Mat(
	Dim		Dim_
	Fill		Fill(
	Seq		Seq(
	Min		Min(
	Max		Max(
	Mean		Mean(
	Med		Median(
	Aug		Augment(
	Sum		Sum_
	Prod		Prod_
	Cuml		Cuml_
	%		Percent_
	⊿		⊿List_
MAT	Mat		Mat_
	M→L		Mat→List(
	Det		Det_
	Trn		Trn_
	Aug		Augment(
	Iden		Identity_
	Dim		Dim_
	Fill		Fill(
	Ref		Ref_
	Rref		Rref_
CPLX	i		i
	Abs		Abs_
	Arg		Arg_
	Conj		Conjg_
	ReP		ReP_
	ImP		ImP_
	▶r∠θ		▶r∠θ
	▶a+bi		▶a+bi
CALC	Solve		Solve(
	d/dx		d/dx(
	d^2/dx^2		d^2/dx^2(
	∫dx		∫(
	SolveN		SolveN(
	FMin		FMin(
	FMax		FMax(
	Σ(		Σ(
	log$_a$b		log$_a$b(
	Int÷		Int÷
	Rmdr		Rmdr
	Simp		▶Simp
STAT	x̂		x̂
	ŷ		ŷ
	DIST		*5
	S·Dev		StdDev(
	Var		Variance(
	TEST		*6
CONV	▶		▶
	LENG	fm	[fm]
		Å	[Å]
		µm	[µm]
		mm	[mm]
		cm	[cm]
		m	[m]
		km	[km]
		AU	[AU]
		l.y.	[l.y.]
		pc	[pc]
		Mil	[Mil]
		in	[in]
		ft	[ft]
		yd	[yd]
		fath	[fath]
		rd	[rd]
		mile	[mile]
		n mile	[n mile]
	AREA	cm^2	[cm^2]
		m^2	[m^2]
		ha	[ha]
		km^2	[km^2]
		in^2	[in^2]
		ft^2	[ft^2]
		yd^2	[yd^2]
		acre	[acre]
		mile^2	[mile^2]
	VLUM	cm^3	[cm^3]
		mL	[mL]
		L	[L]
		m^3	[m^3]
		in^3	[in^3]
		ft^3	[ft^3]
		fl_oz(UK)	[fl_oz(UK)]
		fl_oz(US)	[fl_oz(US)]
		gal(US)	[gal(US)]
		gal(UK)	[gal(UK)]
		pt	[pt]
		qt	[qt]
		tsp	[tsp]
		tbsp	[tbsp]
		cup	[cup]
	TIME	ns	[ns]
		µs	[µs]
		ms	[ms]
		s	[s]
		min	[min]
		h	[h]
		day	[day]
		week	[week]
		yr	[yr]
		s-yr	[s-yr]
		t-yr	[t-yr]
	TMPR	°C	[°C]
		K	[K]
		°F	[°F]
		°R	[°R]
	VELO	m/s	[m/s]
		km/h	[km/h]
		knot	[knot]
		ft/s	[ft/s]
		mile/h	[mile/h]
	MASS	u	[u]
		mg	[mg]
		g	[g]
		kg	[kg]
		mton	[mton]
		oz	[oz]
		lb	[lb]
		slug	[slug]
		ton(short)	[ton(short)]
		ton(long)	[ton(long)]
	RORC	N	[N]
		lbf	[lbf]
		tonf	[tonf]
		dyne	[dyne]
		kgf	[kgf]
	PRES	Pa	[Pa]
		kPa	[kPa]
		mmH$_2$O	[mmH$_2$O]
		mmHg	[mmHg]
		atm	[atm]
		inH$_2$O	[inH$_2$O]
		inHg	[inHg]
		lbf/in^2	[lbf/in^2]
		bar	[bar]
		kgf/cm^2	[kgf/cm^2]
	ENGY	eV	[eV]
		J	[J]
		cal$_{th}$	[cal$_{th}$]
		cal$_{15}$	[cal$_{15}$]
		cal$_{IT}$	[cal$_{IT}$]
		kcal$_{th}$	[kcal$_{th}$]
		kcal$_{15}$	[kcal$_{15}$]
		kcal$_{IT}$	[kcal$_{IT}$]
		l-atm	[l-atm]
		kW•h	[kW•h]
		ft•lbf	[ft•lbf]
		Btu	[Btu]
		erg	[erg]
		kgf•m	[kgf•m]
	PWR	W	[W]
		cal$_{th}$/s	[cal$_{th}$/s]
		hp	[hp]
		ft•lbf/s	[ft•lbf/s]
		Btu/min	[Btu/min]
HYP	sinh		sinh_
	cosh		cosh_
	tanh		tanh_
	sinh^{-1}		sinh^{-1}_
	cosh^{-1}		cosh^{-1}_
	tanh^{-1}		tanh^{-1}_
PROB	X!		!
	nPr		P
	nCr		C
	RAND	Ran#	Ran#_
		Int	RanInt#(
		Norm	RanNorm#(
		Bin	RanBin#(
		List	RanList#(
	P(		P(
	Q(		Q(
	R(		R(
	t(		t(

NUM	Abs		**Abs_**
	Int		**Int_**
	Frac		**Frac_**
	Rnd		**Rnd**
	Intg		**Intg_**
	RndFi		**RndFix(**
	GCD		**GCD(**
	LCM		**LCM(**
	MOD		**MOD(**
	MOD•E		**MOD_Exp(**
ANGL	°		**°**
	r		**r**
	g		**g**
	° ' "		**◘**
	Pol(		**Pol(**
	Rec(		**Rec(**
	▶DMS		**▶DMS**
ESYM	m		**m**
	μ		**μ**
	n		**n**
	p		**p**
	f		**f**
	k		**k**
	M		**M**
	G		**G**
	T		**T**
	P		**P**
	E		**E**
PICT	Sto		**StoPict_**
	Rcl		**RclPict_**
FMEM	fn		**fn**
LOGIC	And		**_And_**
	Or		**_Or_**
	Not		**Not_**
	Xor		**Xor_**
CAPT	Rcl		**RclCapt_**
TVM	SMPL	SI	**Smpl_SI(**
		SFV	**Smpl_SFV(**
	CMPD	n	**Cmpd_n(**
		I%	**Cmpd_I%(**
		PV	**Cmpd_PV(**
		PMT	**Cmpd_PMT(**
		FV	**Cmpd_FV(**
	CASH	NPV	**Cash_NPV(**
		IRR	**Cash_IRR(**
		PBP	**Cash_PBP(**
		NFV	**Cash_NFV(**
	AMT	BAL	**Amt_BAL(**
		INT	**Amt_INT(**
		PRN	**Amt_PRN(**
		ΣINT	**Amt_ΣINT(**
		ΣPRN	**Amt_ΣPRN(**
	CNVT	EFF	**Cnvt_EFF(**
		APR	**Cnvt_APR(**
	COST	Cost	**Cost(**
		Sell	**Sell(**
		Mrg	**Margin(**
	DAYS	PRD	**Days_Prd(**
	BOND	PRC	**Bond_PRC(**
		YLD	**Bond_YLD(**

VARS key

Level 1	Level 2	Level 3	Command
V-WIN	X	min	**Xmin**
		max	**Xmax**
		scal	**Xscl**
		dot	**Xdot**
	Y	min	**Ymin**
		max	**Ymax**
		scal	**Yscl**
	T,θ	min	**Tθmin**
		max	**Tθmax**
		ptch	**Tθptch**
	R-X	min	**RightXmin**
		max	**RightXmax**
		scal	**RightXscl**
		dot	**RightXdot**
	R-Y	min	**RightYmin**
		max	**RightYmax**
		scal	**RightYscl**
	R-T,θ	min	**RightTθmin**
		max	**RightTθmax**
		ptch	**RightTθptch**
FACT	Xfct		**Xfct**
	Yfct		**Yfct**
STAT	X	n	**n**
		$\bar{x}$	**$\bar{x}$**
		Σx	**Σx**
		Σx^2	**Σx^2**
		σ_x	**σ_x**
		S_x	**S_x**
		minX	**minX**
		maxX	**maxX**
	Y	$\bar{y}$	**$\bar{y}$**
		Σy	**Σy**
		Σy^2	**Σy^2**
		Σxy	**Σxy**
		σ_y	**σ_y**
		S_y	**S_y**
		minY	**minY**
		maxY	**maxY**
	GRPH	a	**a**
		b	**b**
		c	**c**
		d	**d**
		e	**e**
		r	**r**
		r^2	**r^2**
		MSe	**MSe**
		Q_1	**Q_1**
		Med	**Med**
		Q_3	**Q_3**
		Mod	**Mod**
		Strt	**H_Start**
		Pitch	**H_pitch**
	PTS	x_1	**x_1**
		y_1	**y_1**
		x_2	**x_2**
		y_2	**y_2**
		x_3	**x_3**
		y_3	**y_3**

	INPT	n	**n**
		$\bar{x}$	**$\bar{x}$**
		S_x	**S_x**
		n1	**n1**
		n2	**n2**
		$\bar{x}_1$	**$\bar{x}_1$**
		$\bar{x}_2$	**$\bar{x}_2$**
		S_{x1}	**S_{x1}**
		S_{x2}	**S_{x2}**
		S_p	**S_p**
	RESLT	*7	
GRPH	Y		**Y**
	r		**r**
	Xt		**Xt**
	Yt		**Yt**
	X		**X**
DYNA	Strt		**D_Start**
	End		**D_End**
	Pitch		**D_pitch**
TABL	Strt		**F_Start**
	End		**F_End**
	Pitch		**F_pitch**
	Reslt		**F_Result**
RECR	FORM	a_n	**a_n**
		a_{n+1}	**a_{n+1}**
		a_{n+2}	**a_{n+2}**
		b_n	**b_n**
		b_{n+1}	**b_{n+1}**
		b_{n+2}	**b_{n+2}**
		c_n	**c_n**
		c_{n+1}	**c_{n+1}**
		c_{n+2}	**c_{n+2}**
	RANG	Strt	**R_Start**
		End	**R_End**
		a_0	**a_0**
		a_1	**a_1**
		a_2	**a_2**
		b_0	**b_0**
		b_1	**b_1**
		b_2	**b_2**
		c_0	**c_0**
		c_1	**c_1**
		c_2	**c_2**
		a_nSt	**a_nStart**
		b_nSt	**b_nStart**
		c_nSt	**c_nStart**
	Reslt		**R_Result**
EQUA	S-Rlt		**Sim_Result**
	S-Cof		**Sim_Coef**
	P-Rlt		**Ply_Result**
	P-Cof		**Ply_Coef**
TVM	n		**n**
	I%		**I%**
	PV		**PV**
	PMT		**PMT**
	FV		**FV**
	P/Y		**P/Y**
	C/Y		**C/Y**
Str			**Str_**

SHIFT VARS (PRGM) key

Level 1	Level 2	Level 3	Command
COM	If		If_
	Then		Then_
	Else		Else_
	I-End		IfEnd
	For		For_
	To		_To_
	Step		_Step_
	Next		Next
	Whle		While_
	WEnd		WhileEnd
	Do		Do
	Lp-W		LpWhile_
CTL	Prog		Prog_
	Rtrn		Return
	Brk		Break
	Stop		Stop
JUMP	Lbl		Lbl_
	Goto		Goto_
	⇒		⇒
	Isz		Isz_
	Dsz		Dsz_
	Menu		Menu_
?			?
◢			◢
CLR	Text		ClrText
	Grph		ClrGraph
	List		ClrList_
	Mat		ClrMat_
DISP	Stat		DrawStat
	Grph		DrawGraph
	Dyna		DrawDyna
	F-Tbl	Tabl	DispF-Tbl
		G-Con	DrawFTG-Con
		G-Plt	DrawFTG-Plt
	R-Tbl	Tabl	DispR-Tbl
		Phase	PlotPhase
		Web	DrawWeb_
		an-Cn	DrawR-Con
		Σa-Cn	DrawR Σ-Con
		an-Pl	DrawR-Plt
		Σa-Pl	DrawR Σ-Plt
REL	=		=
	≠		≠
	>		>
	<		<
	≥		≥
	≤		≤
I/O	Lcte		Locate_
	Gtky		Getkey
	Send		Send(
	Recv		Receive(
	S38k		Send38k_
	R38k		Receive38k_
	Open		OpenComport38k
	Close		CloseComport38k
:			:
STR	Join		StrJoin(
	Len		StrLen(
	Cmp		StrCmp(
	Src		StrSrc(
	Left		StrLeft(
	Right		StrRight(
	Mid		StrMid(
	E▶S		Exp▶Str(
	Exp		Exp(
	Upr		StrUpr(
	Lwr		StrLwr(
	Inv		StrInv(
	Shift		StrShift(
	Rot		StrRotate(

SHIFT MENU (SET UP) key

Level 1	Level 2	Level 3	Command
ANGL	Deg		Deg
	Rad		Rad
	Gra		Gra
COOR	On		CoordOn
	Off		CoordOff
GRID	On		GridOn
	Off		GridOff
AXES	On		AxesOn
	Off		AxesOff
LABL	On		LabelOn
	Off		LabelOff
DISP	Fix		Fix_
	Sci		Sci_
	Norm		Norm_
	Eng	On	EngOn
		Off	EngOff
		Eng	Eng
S/L	—		S-L-Normal
	—		S-L-Thick
	·····		S-L-Broken
	······		S-L-Dot
DRAW	Con		G-Connect
	Plot		G-Plot
DERV	On		DerivOn
	Off		DerivOff
BACK	None		BG-None
	Pict		BG-Pict_
FUNC	On		FuncOn
	Off		FuncOff
SIML	On		SimulOn
	Off		SimulOff
S-WIN	Auto		S-WindAuto
	Man		S-WindMan
LIST	File		File_
LOCS	On		LocusOn
	Off		LocusOff
T-VAR	Rang		VarRange
	List		VarList_
ΣDSP	On		ΣdispOn
	Off		ΣdispOff
RESID	None		Resid-None
	List		Resid-List_
CPLX	Real		Real
	a+bi		a+bi
	r∠θ		r∠θ
FRAC	d/c		d/c
	ab/c		ab/c
Y·SPD	Norm		Y=DrawSpeedNorm
	High		Y=DrawSpeedHigh
DATE	365		DateMode365
	360		DateMode360
PMT	Bgn		PmtBgn
	End		PmtEnd
PRD	Annu		PeriodsAnnual
	Semi		PeriodsSemi
INEQ	And		IneqTypeAnd
	Or		IneqTypeOr
SIMP	Auto		SimplfyAuto
	Man		SimplfyMan
Q1Q3	Std		Q1Q3TypeStd
	OnD		Q1Q3TypeOnData

SHIFT key

Level 1	Level 2	Level 3	Command
ZOOM	Fact		Factor_
	Auto		ZoomAuto
V-WIN	V-Win		ViewWindow_
	Sto		StoV-Win_
	Rcl		RclV-Win_
SKTCH	Cls		Cls
	Tang		Tangent_
	Norm		Normal_
	Inv		Inverse_
	GRPH	Y=	Graph_Y=
		r=	Graph_r=
		Parm	Graph(X,Y)=(
		X=c	Graph_X=
		G-∫dx	Graph_∫
		Y>	Graph_Y>
		Y<	Graph_Y<
		Y≥	Graph_Y≥
		Y≤	Graph_Y≤
		X>	Graph_X>
		X<	Graph_X<
		X≥	Graph_X≥
		X≤	Graph_X≤
	PLOT	Plot	Plot_
		Pl-On	PlotOn_
		Pl-Off	PlotOff_
		Pl-Chg	PlotChg_
	LINE	Line	Line
		F-Line	F-Line_
	Crcl		Circle_
	Vert		Vertical_
	Hztl		Horizontal_
	Text		Text_
	PIXL	On	PxlOn_
		Off	PxlOff_
		Chg	PxlChg_
	Test		PxlTest(

	STYL	—	SketchNormal_
		—	SketchThick_
		·····	SketchBroken_
		······	SketchDot_

BASE Program

F4 (MENU) key

Level 1	Level 2	Level 3	Command
d~o	d		d
	h		h
	b		b
	o		o
LOG	Neg		Neg_
	Not		Not_
	and		and
	or		or
	xor		xor
	xnor		xnor
DISP	▶Dec		▶Dec
	▶Hex		▶Hex
	▶Bin		▶Bin
	▶Oct		▶Oct

SHIFT VARS (PRGM) key

Level 1	Level 2	Level 3	Command
Prog			Prog_
JUMP	Lbl		Lbl_
	Goto		Goto_
	⇒		⇒
	Isz		Isz_
	Dsz		Dsz_
	Menu		Menu_
?			?
◢			◢
REL	=		=
	≠		≠
	>		>
	<		<
	≥		≥
	≤		≤
:			:

SHIFT MENU (SET UP) key

Level 1	Level 2	Level 3	Command
Dec			Dec
Hex			Hex
Bin			Bin
Oct			Oct

	Level 3	Level 4	Command
*1	Exp	ae^bx	Exp(ae^bx)
		ab^x	Exp(ab^x)
*2	MARK	◘	Square
		×	Cross
		■	Dot
	STICK	Leng	StickLength
		Hztl	StickHoriz
	%DATA	%	%
		Data	Data
	None		None
*3	X	ax+b	LinearReg(ax+b)
		a+bx	LinearReg(a+bx)
*4	EXP	ae^bx	ExpReg(a•e^bx)
		ab^x	ExpReg(a•b^x)
*5	NORM	NPd	NormPD(
		NCd	NormCD(
		InvN	InvNormCD(
	t	TPd	tPD(
		TCd	tCD(
		Invt	InvTCD(
	CHI	CPd	ChiPD(
		CCd	ChiCD(
		InvC	InvChiCD(
	F	FPd	FPD(
		FCd	FCD(
		InvF	InvFCD(
	BINM	BPd	BinomialPD(
		BCd	BinomialCD(
		InvB	InvBinomialCD(
	POISN	PPd	PoissonPD(
		PCd	PoissonCD(
		InvP	InvPoissonCD(
	GEO	GPd	GeoPD(
		GCd	GeoCD(
		InvG	InvGeoCD(
	H·GEO	HPd	HypergeoPD(
		HCd	HypergeoCD(
		InvH	InvHyperGeoCD(
*6	Z	1-S	OneSampleZTest_
		2-S	TwoSampleZTest_
		1-P	OnePropZTest_
		2-P	TwoPropZTest_
	t	1-S	OneSampleTTest_
		2-S	TwoSampleTTest_
		REG	LinRegTTest_
	Chi	GOF	ChiGOFTest_
		2-WAY	ChiTest_
	F		TwoSampleFTest_
	ANOV	1-W	OneWayANOVA_
		2-W	TwoWayANOVA_
*7	TEST	p	p
		z	z
		t	t
		Chi	χ^2
		F	F
		$\hat{p}$	$\hat{p}$
		$\hat{p}_1$	$\hat{p}_1$
		$\hat{p}_2$	$\hat{p}_2$
		df	df
		S_e	S_e
		r	r
		r^2	r^2
		pa	pa
		Fa	Fa
		Adf	Adf
		SSa	SSa
		MSa	MSa
		pb	pb
		Fb	Fb
		Bdf	Bdf
		SSb	SSb
		MSb	MSb
		pab	pab
		Fab	Fab
		ABdf	ABdf
		SSab	SSab
		MSab	MSab
		Edf	Edf
		SSe	SSe
		MSe	MSe
	INTR	Left	Left
		Right	Right
		$\hat{p}$	$\hat{p}$
		$\hat{p}_1$	$\hat{p}_1$
		$\hat{p}_2$	$\hat{p}_2$
		df	df
	DIST	p	p
		xInv	xInv
		x1Inv	x1Inv
		x2Inv	x2Inv
		zLow	zLow
		zUp	zUp
		tLow	tLow
		tUp	tUp

8. Program Library

- Be sure to check how many bytes of unused memory are remaining before attempting to perform any programming.

Program Name Prime Factorization

Description

This program continually divides a natural number by factors until all its prime factors are produced.

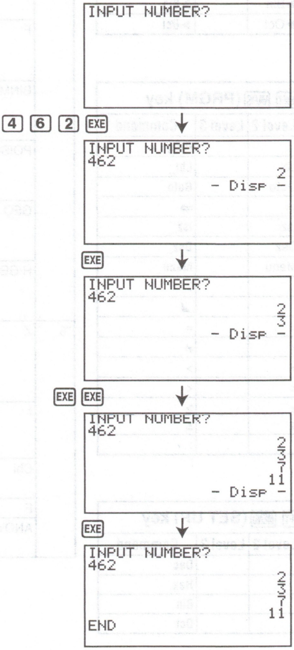
Purpose

This program accepts input of natural number A, and divides it by B (2, 3, 5, 7....) to find the prime factors of A.

- If a division operation does not produce a remainder, the result of the operation is assigned to A.
- The above procedure is repeated until B > A.

Example 462 = 2 × 3 × 7 × 11

```
ClrText↵
"INPUT NUMBER"?→A↵
2→B↵
Do↵
While Frac (A÷B)=0↵
B◢
A÷B→A↵
WhileEnd↵
If B=2↵
Then 3→B↵
Else B+2→B↵
IfEnd↵
LpWhile B≤A↵
"END"
```



```
INPUT NUMBER?
```

```
INPUT NUMBER?
462
                   2
          - Disp -
```

```
INPUT NUMBER?
462
                   2
                   3
          - Disp -
```

```
INPUT NUMBER?
462
                   2
                   3
                   7
                  11
          - Disp -
```

```
INPUT NUMBER?
462
                   2
                   3
                   7
                  11
END
```

Program Name **Ellipse**

Description

This program displays a number table of the following values based on input of the foci of an ellipse, the sum of the distance between the loci and foci, and the pitch (step size) of X.

Y1: Coordinate values of upper half of ellipse

Y2: Coordinate values of lower half of ellipse

Y3: Distances between right focus and loci

Y4: Distances between left focus and loci

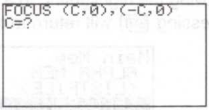
Y5: Sum of Y3 and Y4

Next, the program plots the foci and values in Y1 and Y2.

Purpose

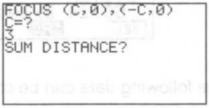
This program shows that the sums of the distances between the loci and two foci of an ellipse are equal.

```
AxesOff↵
Do↵
ClrText↵
"FOCUS (C,0),(-C,0)"↵
"C="?→C↵
"SUM DISTANCE"?→D↵
LpWhile 2Abs C≥D Or D≤0↵
D÷2→A↵
√(A²-C²)→B↵
Y=Type↵
"B√(1-X²÷A²)"→Y1↵
"-Y1"→Y2↵
"√((X-C)²+Y1²)"→Y3↵
"√((X+C)²+Y1²)"→Y4↵
"Y3+Y4"→Y5↵
For 1→E To 20↵
If E≤5↵
Then T SelOn E↵
Else T SelOff E↵
IfEnd↵
Next↵
-Int A→F Start↵
Int A→F End↵
"F pitch"?→F pitch↵
DispF-Tbl◢
ClrGraph↵
1.2A→Xmax↵
-1.2A→Xmin↵
1.2B→Ymax↵
-1.2B→Ymin↵
T SelOff 3↵
T SelOff 4↵
T SelOff 5↵
DispF-Tbl↵
DrawFTG-Plt↵
PlotOn C,0↵
PlotOn -C,0◢
"END"
```



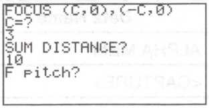
```
FOCUS (C,0),(-C,0)
C=?
```

3 EXE



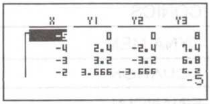
```
FOCUS (C,0),(-C,0)
C=?
3
SUM DISTANCE?
```

1 0 EXE



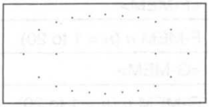
```
FOCUS (C,0),(-C,0)
C=?
3
SUM DISTANCE?
10
F pitch?
```

1 EXE



```
    X      Y1      Y2     Y3
   -5       0       0      8
   -4     2.4    -2.4    7.4
   -3     3.2    -3.2    6.8
   -2   3.666  -3.666    6.2
                          -5
```

EXE

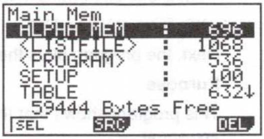


Chapter 9 Memory Manager

You can use Memory Manager to list data stored in calculator memory on the display. You can search and delete data on the list.

1. Using the Memory Manager

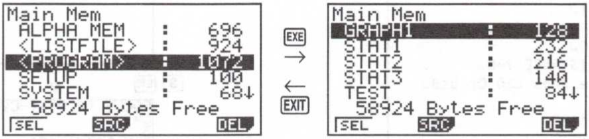
From the Main Menu, select the **MEMORY** icon to enter the **MEMORY** mode and display its initial screen.



```
Main Mem
 ALPHA MEM     :   696
 <LISTFILE>    :  1068
 <PROGRAM>     :   536
 SETUP         :   100
 TABLE         :   632↓
 59444 Bytes Free
```

- Use the cursor ⏶ and ⏷ keys to move the highlighting and check the number of bytes used by each type of data.
- Line 7 shows how many bytes of memory are currently unused.
- On the main memory screen, < > indicates a data group.

Moving the highlighting to a data group and pressing EXE will display the data group contents. Pressing EXIT will return to the previous screen.



```
Main Mem
 ALPHA MEM     :   696
 <LISTFILE>    :   924
 <PROGRAM>     :  1072
 SETUP         :   100
 SYSTEM        :    68↓
 58924 Bytes Free
```

```
Main Mem
 GRAPH1        :   128
 STAT1         :   232
 STAT2         :   216
 STAT3         :   140
 TEST          :    84↓
 58924 Bytes Free
```

The following data can be checked.

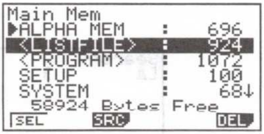
Main Memory

Data Name	Contents
ALPHA MEM	Alpha letter variables
<CAPTURE>	Capture memory group
CAPT *n* (*n* = 1 to 20)	Capture memory
CONICS	Conics setting data
DYNA MEM	Dynamic Graph memory
EQUATION	Equation data
FINANCIAL	Financial data
<F-MEM>	Function memory group
F-MEM *n* (*n* = 1 to 20)	Function memory
<G-MEM>	Graph memory group
G-MEM *n* (*n* = 1 to 20)	Graph memory
<LISTFILE>	List file group
LIST *n* (*n* = 1 to 26, and Ans)	List memory contents
LIST FILE *n* (*n* = 1 to 6)	List file

Data Name	Contents
<MATRIX>	Matrix group
MAT *n* (*n* = A to Z, and Ans)	Matrix
<PICTURE>	Picture memory group
PICT *n* (*n* = 1 to 20)	Picture memory
<PROGRAM>	Program group
Each program name	Programs
RECURSION	Recursion data
SETUP	Setup data
STAT	Stat result data
<STRING>	String memory group
STR *n* (*n* = 1 to 20)	String memory
SYSTEM	OS and data shared by applications (clipboard, replay, history, etc.)
TABLE	Table data
<V-WIN>	V-Window memory group
V-WIN *n* (*n* = 1 to 6)	V-Window memory
Y=DATA	Graph expression

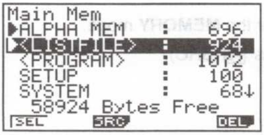
■ Selecting Data

- Press F1(SEL) to select the currently highlighted item, which is indicated by the black selection pointer (▶) appearing next to it. Pressing F1(SEL) again will deselect the item, causing the selection pointer to disappear.
- You can select multiple files, if you want.



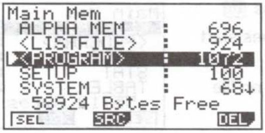
```
Main Mem
▶ALPHA MEM  :   696
 <LISTFILE> :   924
 <PROGRAM>  :  1072
 SETUP      :   100
 SYSTEM     :    68↓
  58924 Bytes Free
SEL    SRC       DEL
```

→
F1(SEL)
←



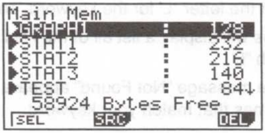
```
Main Mem
▶ALPHA MEM  :   696
▶<LISTFILE> :   924
 <PROGRAM>  :  1072
 SETUP      :   100
 SYSTEM     :    68↓
  58924 Bytes Free
SEL    SRC       DEL
```

- Selecting a group or folder also selects everything inside of it. Deselecting a group or folder deselects all of its contents.



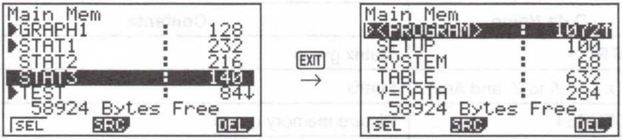
```
Main Mem
 ALPHA MEM  :   696
 <LISTFILE> :   924
▶<PROGRAM>  :  1072
 SETUP      :   100
 SYSTEM     :    68↓
  58924 Bytes Free
SEL    SRC       DEL
```

EXE
→



```
Main Mem
▶GRAPH1     :   128
▶STAT1      :   232
▶STAT2      :   216
▶STAT3      :   140
▶TEST       :    84↓
  58924 Bytes Free
SEL    SRC       DEL
```

- If you select one or more individual items inside of a data group or folder, the black selection pointer (▶) appears next to each item, while a white selection pointer (▷) appears next to the group or folder name.



```
Main Mem
▶GRAPH1       :   128
▶STAT1        :   232
 STAT2        :   216
 STAT3        :   140
▶TEST         :    84↓
  58924 Bytes Free
```

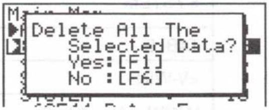
```
Main Mem
▷<PROGRAM>    : 10724↑
 SETUP        :   100
 SYSTEM       :    68
 TABLE        :   632
 Y=DATA       :   284
  58924 Bytes Free
```

- Returning to the **MEMORY** mode initial screen deselects all currently selected items.

Deleting Files

• To delete a file

1. Enter the **MEMORY** mode.
   - This displays a list of files that are in the main memory.
2. Select the file(s) you want to delete. You can select multiple files, if you want.
3. Press F6 (DEL).
   - Press F1 (Yes) to delete the file.
   - Press F6 (No) to cancel the delete operation.



```
Delete All The
    Selected Data?
    Yes:[F1]
    No :[F6]
```

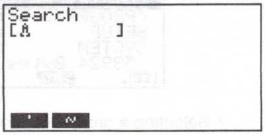
Searching for a File Name

You can specify a string of up to eight characters and search for file names that start with the characters. All of the files whose names start with the specified characters are listed on the screen.

• To search for a file

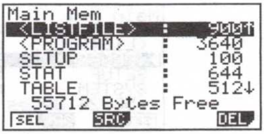
Example **To find all files whose names start with "L"**

1. Enter the **MEMORY** mode.
2. Press F3 (SRC).



```
Search
[A       ]
```

3. Input the letter "L" for the keyword, and then press EXE.
   - This will display a list all of the files whose names start with "L".
   - The message "Not Found" appears if there are no file names that match your keyword.



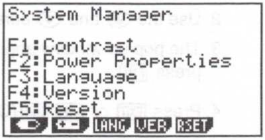
```
Main Mem
 <LISTFILE>   :  9000↑
 <PROGRAM>    :  3640
 SETUP        :   100
 STAT         :   644
 TABLE        :   512↓
  55712 Bytes Free
```

Chapter 10 System Manager

Use the System Manager to view system information and make system settings.

1. Using the System Manager

From the Main Menu, enter the **SYSTEM** mode and display the following menu items.



System Manager

F1:Contrast
F2:Power Properties
F3:Language
F4:Version
F5:Reset

- F1(◐) ... {display contrast adjustment}
- F2(▭) ... {Auto Power Off time setting}
- F3(LANG) ... {system language}
- F4(VER) ... {version}
- F5(RSET) ... {system reset operations}

2. System Settings

■ Contrast Adjustment

Use the ◐ (Contrast) item to adjust display contrast.

While the initial **SYSTEM** mode screen is displayed, press F1(◐) to display the Contrast Adjustment screen.

- The ▶ cursor key makes display contrast darker.
- The ◀ cursor key makes display contrast lighter.
- F1(INIT) returns display contrast to its initial default.

Press EXIT or SHIFT EXIT(QUIT) to return to the initial **SYSTEM** mode screen.

You can adjust contrast while any screen is on the display by pressing SHIFT and then ▶ or ◀. To exit contrast adjustment, press SHIFT again.

■ Power Properties

You can specify either ten minutes or 60 minutes as the Auto Power Off trigger time. The initial default setting is ten minutes.

While the initial **SYSTEM** mode screen is displayed, press F2(▭) to display the Auto Power Off Setting screen.

- F1(10) ... 10 minutes
- F2(60) ... 60 minutes

Press EXIT or SHIFT EXIT(QUIT) to return to the initial **SYSTEM** mode screen.

System Language Setting

Use LANG to specify the display language for built-in applications.

• To select the message language

1. From the initial **SYSTEM** mode screen, press F3(LANG) to display the Message Language selection screen.
2. Use the ▲ and ▼ cursor keys to select the language you want, and then press F1(SEL).
3. The pop up window appears using the language you selected. Check the contents and then press EXIT.
4. Press EXIT or SHIFT EXIT(QUIT) to return to the initial **SYSTEM** mode screen.

Version List

Use VER (version) to display the operating system version. You can also register the user name you want.

• To display version information

1. On the initial **SYSTEM** mode screen, press F4(VER) to display the Version list.
2. Use ▲ and ▼ to scroll the screen. The contents of the list are shown below.

   Operating system version

   Message languages and versions

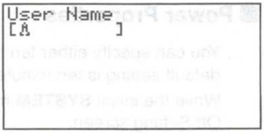
   User name

3. Press EXIT or SHIFT EXIT(QUIT) to return to the initial **SYSTEM** mode screen.

- The operating system version that actually appears depends on the calculator model.

• To register a user name

1. While the Version list is displayed, press F1(NAME) to display the user name input screen.

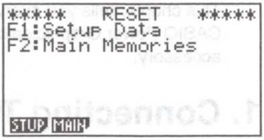


```
User Name
[A       ]
```

2. Input up to eight characters for the user name you want.
3. After inputting the name, press EXE to register it, and return to the Version list.
   - If you want to cancel user name input and return to the Version list without registering a name, press EXIT.

■ Reset

1. While the initial **SYSTEM** mode screen is displayed, press F5(RSET) to display the Reset Screen.
   - F1(STUP) ... {setup initialization}
   - F2(MAIN) ... {main memory data clear}

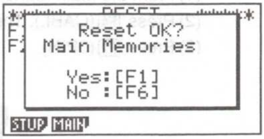


```
*****   RESET   *****
F1:Setup Data
F2:Main Memories
```

Function Key Functions

	Initialize Setup Information	Delete Main Memory Data
F1(STUP)	○	
F2(MAIN)	○	○

2. Press the function key that corresponds to the reset operation you want to perform.
3. In response to the confirmation message that appears, press F1(Yes) to perform the reset operation you specified, or F6(No) to cancel.



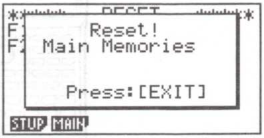
```
Reset OK?
Main Memories

Yes:[F1]
No :[F6]
```

Screen produced when F2(MAIN) is pressed in step 2.

4. A message appears to let you know when the reset operation is complete.

   Press EXIT to clear the message.



```
Reset!
Main Memories


Press:[EXIT]
```

Screen produced when F2(MAIN) is pressed in step 2.

Chapter 11 Data Communications

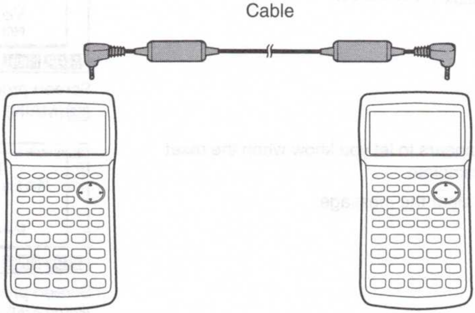
This chapter tells you everything you need to know to transfer programs between two CASIO Power Graphic calculators connected using the cable that is equipped as a standard accessory.

1. Connecting Two Units

The following procedure describes how to connect two units with the connecting cable that comes equipped as a standard accessory.

- **To connect two units**

1. Check to make sure that the power of both units is off.
2. Connect the two units using the cable.
3. Perform the following steps on both units to specify 3PIN as the cable type.
   (1) From the Main Menu, enter the **LINK** mode.
   (2) Press F4(CABL). This displays the cable type selection screen.
   (3) Press F2(3PIN).



- Models that are supported for this configuration are shown below.

  fx-9860GII SD, fx-9860GII, fx-9860G AU PLUS, fx-9750GII, fx-7400GII, fx-9860G Slim (OS 1.11), fx-9860G SD (OS 2.00/1.05), fx-9860G (OS 2.00/1.05), fx-9860G AU (OS 2.00/1.05), fx-7400G series, CFX-9850G series

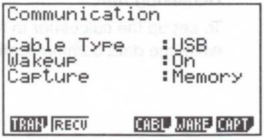
2. Connecting the Calculator to a Personal Computer

You can connect the calculator to a computer using the cable that comes with the separately available Program-Link Software (FA-124), and then transfer data between them.

For details about establishing a connection and data transfer procedures, see the FA-124 User's Guide.

3. Performing a Data Communication Operation

From the Main Menu, enter the **LINK** mode. The following data communication main menu appears on the display.


Communication
Cable Type :USB
Wakeup :On
Capture :Memory

- {**TRAN**} ... {displays the data send screen}
- {**RECV**} ... {displays the data receive screen}
- {**CABL**} ... {displays the cable type selection screen}
- {**WAKE**} ... {displays the wakeup setting screen}
- {**CAPT**} ... {displays the screen image send setting screen}

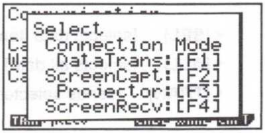
Communication parameters are fixed at the following settings.

- 3-pin serial port
  - Speed (BPS): 9600 bps max. (Connected with CFX-9850G series or fx-7400G series calculator)

    115200 bps max. (Connected with another fx-9860GII SD, fx-9860GII, fx-9860G AU PLUS, fx-9750GII, fx-7400GII, fx-9860G Slim (OS 1.11), fx-9860G SD (OS 2.00/1.05), fx-9860G (OS 2.00/1.05) or fx-9860G AU (OS 2.00/1.05) calculator)
  - Parity (PARITY): NONE
- USB port
  - Communication speed is in accordance with USB standards.

■ Select Connection Mode Screen

Connecting the USB cable to the calculator will cause the dialog box shown nearby to appear. You can use this dialog box to select the USB cable Connection Mode (screen image send mode).


Select
Connection Mode
DataTrans:[F1]
ScreenCapt:[F2]
Projector:[F3]
ScreenRecv:[F4]

- F1(DataTrans) ... {mode selection for data transfer with PC}
- F2(ScreenCapt) ... {mode selection for sending calculator screen captures to PC using FA-124 Screen Capture function}
- F3(Projector) ... {mode selection for calculator screen output to a CASIO OHP unit or CASIO projector}
- F4(ScreenRecv) ... {mode selection for sending calculator screen images to PC using fx-9860GII Manager PLUS Screen Receiver function}

To transfer data between a PC and calculator memory, press F1.

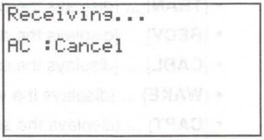
Use keys F2 through F4 to select the appropriate mode for sending the calculator screen image to an external device. For details about calculator operations when keys F2 through F4 are pressed, see "Screen Image Send" (page 11-11).

■ Performing a Data Transfer Operation

Connect the two units and then perform the following procedures.

Receiving unit

To set up the calculator to receive data, press F2(RECV) while the data communication main menu is displayed.



```
Receiving...
AC :Cancel
```

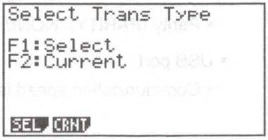
The calculator enters a data receive standby mode and waits for data to arrive. Actual data receive starts as soon as data is sent from the sending unit.

Sending unit

To set up the calculator to send data, press F1(TRAN) while the data communication main menu is displayed.

This displays a screen for specifying the data selection method.

- {**SEL**} ... {selects new data}
- {**CRNT**} ... {automatically selects previously selected data*[1]}



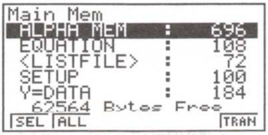
```
Select Trans Type
F1:Select
F2:Current
```

[1] The previously selected data memory is cleared whenever you change to another mode.

• To send selected data items (Example: To send user data)

Press F1(SEL) or F2(CRNT) to display a data item selection screen.

- {**SEL**} ... {selects data item where cursor is located}
- {**ALL**} ... {selects all data}
- {**TRAN**} ... {sends selected data items}



```
Main Mem
 ALPHA MEM    :    696
 EQUATION     :    108
 <LISTFILE>   :     72
 SETUP        :    100
 Y=DATA       :    184
   62564 Bytes Free
```

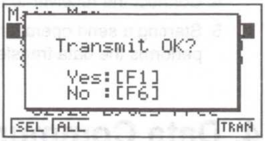
Use the ▲ and ▼ cursor keys to move the cursor to the data item you want to select and press F1(SEL) to select it. Currently selected data items are marked with "►". Pressing F6(TRAN) sends all the selected data items.

- To deselect a data item, move the cursor to it and press F1(SEL) again.

Only items that contain data appear on the data item selection screen. If there are too many data items to fit on a single screen, the list scrolls when you move the cursor to the bottom line of the items on the screen.

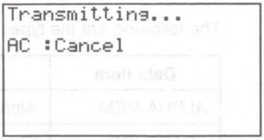
• To execute a send operation

After selecting the data items to send, press F6(TRAN). A message appears to confirm that you want to execute the send operation.


Transmit OK?
Yes:[F1]
No :[F6]

- F1(Yes) ... sends data
- F6(No) ... returns to data selection screen

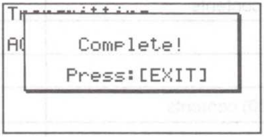
Press F1(Yes) to send the data.


Transmitting...
AC :Cancel

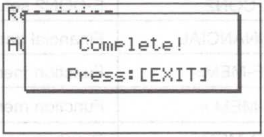
- You can interrupt a data operation at any time by pressing AC.

The following shows what the displays of the sending and receiving units look like after the data communication operation is complete.

Sending Unit


Complete!
Press:[EXIT]

Receiving Unit

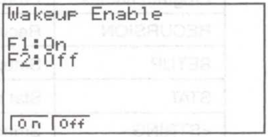

Complete!
Press:[EXIT]

Press EXIT to return to the data communication main menu.

■ Configuring the Receiver's Wakeup Feature

When Wakeup is turned on the receiver, the receiver turns on automatically when data transfer starts.

- When communicating between two calculators (3PIN selected as the cable type), the receiver enters the receive mode automatically after it wakes up.
- When communication is with a computer (USB selected as the cable type), connecting the USB cable to a computer and then to the calculator (while the calculator is turned off) will cause the calculator to turn on and the "Select Connection Mode" dialog box to appear.


Wakeup Enable
F1:On
F2:Off

1. On the receiver's data communication main menu, press F5(WAKE).

   This displays the Wakeup setting screen.

   - {**On**} ... {turns Wakeup on}
   - {**Off**} ... {turns Wakeup off}

2. Press F1(On).

   This turns on Wakeup and returns of the data communication main menu.
3. Turn off the receiver.
4. Connect the receiver to the sender.
5. Starting a send operation on the sender causes the receiver to turn on automatically and performs the data transfer operation.

4. Data Communications Precautions

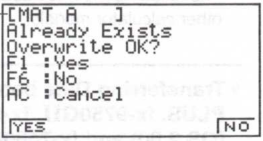
The following are the types of data items that can be sent.

Data Item	Contents	Overwrite Check*[1]
ALPHA MEM	Alpha memory contents	No
<CAPTURE>	Capture memory group	
CAPT *n*	Capture memory (1 to 20) data	No
CONICS	Conics setting data	No
DYNA MEM	Dynamic Graph functions	Yes
EQUATION	Equation calculation coefficient values	No
E-CON2	E-CON2 setup memory contents	No
FINANCIAL	Financial data	No
<F-MEM>	Function memory group	
F-MEM *n*	Function memory (1 to 20) contents	No
<G-MEM>	Graph memory group	
G-MEM *n*	Graph memory (1 to 20) contents	Yes
<LISTFILE>	List file group	
LIST *n*	List memory (1 to 26, and Ans) contents	Yes
LIST FILE *n*	List file memory (1 to 6) contents	Yes
<MATRIX>	Matrix group	
MAT *n*	Matrix memory (A to Z, and Ans) contents	Yes
<PICTURE>	Picture memory group	
PICT *n*	Picture (graph) memory (1 to 20) data	No
<PROGRAM>	Program group	
Program names	Program contents (All programs are listed.)	Yes
RECURSION	Recursion data	No
SETUP	Setup data	No
STAT	Stat result data	No
<STRING>	String memory group	
STR *n*	String memory (1 to 20) data	No

Data Item	Contents	Overwrite Check[*1]
SYSTEM	OS and data shared by applications (clipboard, replay, history, etc.)	No
TABLE	Table data	No
<V-WIN>	V-Window memory group	
V-WIN n	V-Window memory (1 to 6) contents	No
Y=DATA	Graph expressions, graph draw/non-draw status, V-Window contents, zoom factors	No

[*1] No overwrite check: If the receiving unit already contains the same type of data, the existing data is overwritten with the new data.

With overwrite check: If the receiving unit already contains the same type of data, a message appears to ask if the existing data should be overwritten with the new data.



Data item name

```
[MAT A    ]
Already Exists
Overwrite OK?
F1 :Yes
F6 :No
AC :Cancel
```

- F1 (YES) ... {replaces the receiving unit's existing data with the new data}
- F6 (NO) ... {skips to next data item}

Note the following precautions whenever you perform data communications.

- An error occurs whenever you try to send data to a receiving unit that is not yet standing by to receive data. When this happens, press EXIT to clear the error and try again, after setting up the receiving unit to receive data.
- An error occurs whenever the receiving unit does not receive any data approximately six minutes after it is set up to receive data. When this happens, press EXIT to clear the error.
- An error occurs during data communications if the cable becomes disconnected, if the parameters of the two units do not match, or if any other communications problem occurs. When this happens, press EXIT to clear the error, then correct the problem before trying data communications again. If data communications are interrupted by the EXIT key operation or an error, any data successfully received up to the interruption will be in the memory of the receiving unit.
- An error occurs if the receiving unit memory becomes full during data communications. When this happens, press EXIT to clear the error and delete unneeded data from the receiving unit to make room for the new data, and then try again.

■ Exchanging Data with another Model Calculator

In this section, the term "OS 2.00 calculators" refers to the following models.

- fx-9860GII SD, fx-9860GII, fx-9860G AU PLUS, fx-9750GII, fx-7400GII
- fx-9860G SD, fx-9860G and fx-9860G AU whose operating systems have been updated to Version 2.00

An OS 2.00 calculator supports data exchange with the following calculator models.

OS 2.00 calculators, fx-9860G series, fx-7400G series, CFX-9850G series

When you perform a data exchange operation with the above calculator models, the OS 2.00 calculator will decide whether or not specific data can be sent or received, and convert data as required. The following describes the basic operations that are performed when exchanging data between an OS 2.00 calculator and another model calculator.

- Sending data from the OS 2.00 calculator to another calculator model
  Data that is supported by the OS 2.00 calculator but is not supported by the receiving model either is not sent or is converted to a format supported by the receiving model before it is sent.
- Sending data from another calculator model to an OS 2.00 calculator
  Basically, data sent from another calculator model is received as it is. However, when there is a difference between an OS 2.00 calculator function and the function of the sending model, the OS 2.00 calculator will convert the data as required.

The following provides details about data compatibility between an OS 2.00 calculator and other calculator models.

• Transferring Data between the fx-9860GII SD, fx-9860GII, fx-9860G AU PLUS, fx-9750GII, fx-9860G SD (OS 2.00), fx-9860G (OS 2.00), fx-9860G AU (OS 2.00) and fx-7400GII

Sender: fx-7400GII

Receiver: fx-9860GII SD, fx-9860GII, fx-9860G AU PLUS, fx-9750GII, fx-9860G SD (OS 2.00), fx-9860G (OS 2.00), fx-9860G AU (OS 2.00)

All data transferred.

Sender: fx-9860GII SD, fx-9860GII, fx-9860G AU PLUS, fx-9750GII, fx-9860G SD (OS 2.00), fx-9860G (OS 2.00), fx-9860G AU (OS 2.00)

Receiver: fx-7400GII

- The following data is not sent from the fx-9860GII SD, fx-9860GII, fx-9860G AU PLUS, fx-9860G SD (OS 2.00), fx-9860G (OS 2.00), fx-9860G AU (OS 2.00) or is disregarded when received by the fx-7400GII.
  - **CONICS** mode data
  - **DYNA** mode data
  - **E-CON2** mode data
  - Matrix data
  - **RECUR** mode data
  - **TVM** mode data
  - **STAT** mode function and variable data for which there is no corresponding function for variable on the fx-7400GII (Example: χ^2 GOF Test calculation result data, etc.)
  - Clipboard and history data (Including the "SYSTEM" data item.)
  - **e • ACT** mode data[1]
  - **S • SHT** mode data[1]

[1] Can be transferred from an fx-9860GII SD, fx-9860GII, fx-9860G AU PLUS, fx-9860G SD (OS 2.00), fx-9860G (OS 2.00) or fx-9860G AU (OS 2.00) calculator.

- Program data is transferred as-is.
  However, any command in a transferred program that is not supported by the fx-7400GII will be replaced by the at sign (@). Running such a program on the fx-7400GII will cause an error.

• Sending Data from an OS 2.00 Calculator to any Older Model Calculator

The following are general rules that apply when transferring data from an OS 2.00 calculator to an fx-9860G series or CFX-9850G series calculator.

- The following data is not transferred.
  - String memory data
  - **TVM** mode bond calculation and depreciation calculation data
  - **STAT** mode function and variable data for which there is no corresponding function for variable on the receiving calculator model (Example: χ^2 GOF Test calculation result data, etc.)
- The following data is converted by the OS 2.00 calculator to a format that is supported by the receiving calculator model before it is sent.
  - **GRAPH** mode, **DYNA** mode Graph Type setting data
    When transferring to an fx-9860G series or CFX-9850G series calculator, X=, X>, X<, X≥, and X≤ type expressions are converted to an X=c type expression
  - Graph line type setting data
    When sending to a CFX-9850G series calculator, line settings are converted as follows before being sent: Normal: Blue; Thick: Orange; Broken, Dotted: Green.
  - **STAT** mode Graph1, Graph2, and Graph3 setting data
    When sending to an fx-9860G series calculator, pie and bar type graphs are converted to ScatterPlot before being sent. Other settings are not sent.
- Program data is transferred as-is.
  However, any command in a transferred program that is not supported by the other model calculator will be replaced by the at sign (@). Running such a program on the other model calculator will cause an error.

- Refer to the following if an error message appears on the OS 2.00 calculator when you are sending data to another calculator model.

  Invalid Data Size

  - Matrix data exceeds 256 rows or 256 columns*1
  - List data exceeds 256 lines
  - Table data exceeds 256 rows
  - Recursion table data exceeds 256 lines*1*3
  - **EQUA** mode input data includes 4 to 6-degree equation

  Complex Number in data

  - Matrix data includes an element containing a complex number*1
  - List data includes an element containing a complex number
  - **EQUA** mode simultaneous equation input data has a complex number coefficient
  - **EQUA** mode simultaneous equation calculation result includes a complex number solution

Invalid Data Number

- List data with a number greater than List 6
- Picture data with a number greater than Pict 6[2]
- Function memory data with a number greater than F-Mem 6[2]
- Graph memory data with a number greater than G-Mem 6[2]

[1] Can be transferred from an OS 2.00 calculator except the fx-7400GII.

[2] Can be transferred to an fx-9750G series or CFX-9850G series calculator only.

[3] Can be transferred to an fx-9860G series calculator only.

• Sending Data from an OS 2.00 Calculator to a CFX-9850G Series Calculator

Sender:	OS 2.00 calculator
Receiver:	CFX-9850G series

The following data is not sent from an OS 2.00 calculator or is disregarded when received by the CFX-9850G series calculator.

- Capture memory data
- Clipboard and replay data (Including the "SYSTEM" data item.)
- **CONICS** mode data[1]
- **E-CON2** mode data[1]
- **RECUR** mode c_n (c_{n+1}, c_{n+2}) expressions[1]
- **RECUR** mode table data[1]
- Setup data
- **STAT** mode data
- **TABLE** mode table data
- **TVM** mode data[1]
- V-Window x-dot data
- Calculation results of simultaneous equations and high-order equations

[1] Can be transferred from an OS 2.00 calculator except the fx-7400GII.

• Sending Data from an OS 2.00 Calculator to an fx-7400G Series Calculator

Sender:	OS 2.00 calculator
Receiver:	fx-7400G series

The following data is not sent from the OS 2.00 calculator or is disregarded when received by the fx-7400G series calculator

- Any alpha memory variable (A to Z, r, θ) with a complex number assigned
- Answer Memory
- Capture memory data
- Clipboard and replay data (Including the "SYSTEM" data item.)
- **CONICS** mode data[1]

- **DYNA** mode data[*1]
- **E-CON2** mode data[*1]
- **EQUA** mode data
- Function memory data
- Graph memory data
- Matrix data[*1]
- Picture memory data
- **RECUR** mode data[*1]
- Setup data
- **STAT** mode data
- **TABLE** mode table data
- **TVM** mode data[*1]
- V-Window Memory with number V-Win 2 or greater
- V-Window x-dot data
- Graph expressions excluding Y=$f(x)$ type expression, Y inequalities and parametric expressions

[*1] Can be transferred from an OS 2.00 calculator except the fx-7400GII.

• Sending Data from an fx-9860G Series Calculator to an OS 2.00 Calculator

Sender:	fx-9860G series
Receiver:	OS 2.00 calculator

- X=c type expressions are converted to X= type expressions.

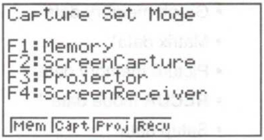
• Sending Data from a CFX-9850G Series Calculator to an OS 2.00 Calculator

Sender:	CFX-9850G series
Receiver:	OS 2.00 calculator

- X=c type expressions are converted to X= type expressions.
- V-Window Xmin and Xmax values are sent as-is. Since, the Xdot value does not exist on the CFX-9850G series calculators, the OS 2.00 calculator calculates it automatically from the Xmin and Xmax values they send.
- Performing the data transfer operation changes the graph memory and dynamic graph memory setup values to their initial defaults.
- When graph expression data is received from a CFX-9850 series calculator, line settings are converted as follows: Blue: Normal; Orange: Thick; Green: Dotted.

5. Screen Image Send

Pressing F6(CAPT) while the data communication main menu is displayed will cause the "Capture Set Mode" screen to appear. You can use this screen to select the screen image send mode.



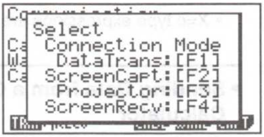
Capture Set Mode

F1:Memory
F2:ScreenCapture
F3:Projector
F4:ScreenReceiver

- F1(Mem) ... {mode selection for data transfer with PC (screen image send turned off)}
- F2(Capt) ... {mode selection for sending calculator screen captures to PC using FA-124 Screen Capture function (manual screen image send turned on)}
- F3(Proj) ... {mode selection for calculator screen output to a CASIO OHP unit or CASIO projector (auto screen image send turned on)}
- F4(Recv) ... {mode selection for sending calculator screen images to PC using fx-9860GII Manager PLUS Screen Receiver function (auto screen image send turned on)}

■ Select Connection Mode Screen

You also can perform the same mode selection operations as the Capture Set Mode screen on the "Select Connection Mode" dialog box that appears when you connect the USB cable to the calculator.



Select
Connection Mode
DataTrans:[F1]
ScreenCapt:[F2]
Projector:[F3]
ScreenRecv:[F4]

The options on the Select Connection Mode screen correspond to the options on the Capture Set Mode screen as follows: F1(DataTrans) = F1(Mem), F2(ScreenCapt) = F2(Capt), F3(Projector) = F3(Proj), F4(ScreenRecv) = F4(Recv).

- The following types of screen images cannot be transferred to another calculator or computer using auto screen image send.
  - The screen displayed during data transfer
  - The screen displayed during a calculation
  - The screen displayed after reset is performed
  - The low battery screen

Transferring Screen Images to a Computer

Use the following procedure to transfer calculator screen images to a computer. Perform this procedure using FA-124 software running on the computer.

1. Use the USB cable to connect the calculator to the computer.
2. On the calculator, press F2(ScreenCapt) in response to the "Select Connection Mode" dialog box that appears when connecting the USB cable to the calculator.
3. On the calculator, display the screen you want to transfer.
4. Use FA-124 to perform the transfer operation.
5. On the calculator, press SHIFT 7(CAPTURE).
6. The screen data is sent to the computer.

Auto Screen Image Send to an OHP Unit

The following procedure sends the screen of this calculator to an OHP unit at fixed intervals.

1. Use the USB cable to connect the calculator to the OHP unit.
   - Connecting the USB cable to the calculator will cause the "Select Connection Mode" dialog box to appear.
2. Press F3(Projector).
3. Display the image you want to send.
4. The displayed image is sent automatically to the OHP unit.
5. To continue with auto screen image send, return to step 3.
6. To stop auto screen image send, press F6(CAPT)F1(Mem) on the data communication main menu.

See the User's Guide that comes with the OHP unit for information about connecting the OHP unit and how to use the calculator while the OHP unit is attached.

Auto Screen Image Send to a Computer Using the fx-9860GII Manager PLUS

Use the following procedure to transfer calculator screen images to a computer. Perform this procedure using fx-9860GII Manager PLUS software running on the computer.

1. After starting up Screen Receiver on the fx-9860GII Manager PLUS software, use the USB cable to connect the calculator to your computer.
   - Connecting the USB cable to the calculator will cause the "Select Connection Mode" dialog box to appear.
2. Press F4(ScreenRecv).
3. On the calculator, display the screen you want to transfer.
4. The displayed image is sent automatically to the computer.
5. To continue with auto screen image send, return to step 3.
6. To stop auto screen image send, press F6(CAPT)F1(Mem) on the data communication main menu.

■ Connecting to a Projector

You can connect the calculator to a CASIO projector and project calculator screen contents onto a screen.

• Connectable Projectors (As of July 2011)

XJ-S35/XJ-S36/XJ-S37/XJ-S39/XJ-S47/XJ-S57/XJ-S58/XJ-S68/XJ-SC215

XJ-A135/XJ-A145/XJ-A155/XJ-A235/XJ-A245

XJ-A135V/XJ-A145V/XJ-A155V/XJ-A235V/XJ-A245V/XJ-A255V

XJ-M145/XJ-M155/XJ-M245/XJ-M255

XJ-H1650/XJ-ST145/XJ-ST155

- You can also connect the calculator to a YP-100 Multifunctional Presentation Kit and project from the projectors other than the model shown above.

• To project calculator screen contents from a projector

1. Use the USB cable that comes with the calculator to connect to the projector (or YP-100 unit).
    - Connecting the USB cable to the calculator will cause the "Select Connection Mode" dialog box to appear.
2. Press F3(Projector).

• Precautions when Connecting

- An hourglass figure may remain projected on the screen after you connect the calculator to a projector (or YP-100). Also, changing to another screen while a graph is being drawn or while a **PRGM** mode program is running could possibly result in the projected screen being different from the calculator screen. If this happens, performing some operation on the calculator will restore normal display.
- If the calculator stops operating normally, disconnect the USB cable and then reconnect it. If this does not correct the problem, disconnect the USB cable, turn the projector (or YP-100) off and then back on, and then reconnect the USB cable.

Appendix

1. Error Message Table

Message	Meaning	Countermeasure
Syntax ERROR	• Illegal syntax • Attempt to input an illegal command	• Press EXIT to display the error and make necessary corrections.
Ma ERROR	• Calculation result exceeds the display range. • Calculation is outside the input range of a function. • Mathematical error (division by zero, etc.) • Sufficient precision could not be obtained for Σ calculation, differential calculation, etc. • Solution could not be obtained for equation calculation, etc.	• Check input values and make corrections to ensure that values are within allowable limits.
Go ERROR	① No corresponding Lbl n for Goto n. ② No program stored in program area Prog "file name".	① Correctly input a Lbl n to correspond to the Goto n, or delete the Goto n if not required. ② Store a program in program area Prog "file name", or delete the Prog "file name" if not required.
Nesting ERROR	• Nesting of subroutines by Prog "file name" exceeds 10 levels.	• Ensure that Prog "file name" is not used to return from subroutines to main routine. If used, delete any unnecessary Prog "file name". • Trace the subroutine jump destinations and ensure that no jumps are made back to the original program area. Ensure that returns are made correctly.
Stack ERROR	• Execution of calculations that exceed the capacity of the stack for numeric values or stack for commands.	• Simplify the formulas to keep stacks within 10 levels for the numeric values and 26 levels for the commands. • Divide the formula into two or more parts.
Memory ERROR	• Operation or memory storage operation exceeds remaining memory capacity.	• Keep the number of memories you use within the currently specified number of memories. • Simplify the data you are trying to store to keep it within the available memory capacity. • Delete no longer needed data to make room for the new data.

Message	Meaning	Countermeasure
Argument ERROR	• Incorrect argument specification for a command that requires an argument.	• Correct the argument.
Dimension ERROR	• Illegal dimension used during matrix or list calculations.	• Check the matrix or list dimension.
Range ERROR	① Input of an improper V-Window value. ② V-Window range settings exceeded when a graph is redrawn. ③ Input of an improper value on the range screen and use of that value for execution.	① Change the V-Window value so it is within range. ② Redraw using the proper settings. ③ Input a proper range value.
Condition ERROR	• Execution of a calculation or function before all conditions required for execution are met.	• Check the conditions and make any necessary corrections.
Non-Real ERROR	• Calculation that produces a complex number when Real is specified for the Complex Mode setting on the Setup screen, even though the argument is a real number.	• Change the Complex Mode setting to something other than Real.
Complex Number In List	• List containing complex number used in a calculation or operation for which complex number data is invalid.	• Change all data in the list to real numbers.
Complex Number in Matrix	• Matrix containing complex number used in a calculation or operation for which complex number data is invalid.	• Change all data in the matrix to real numbers.
Complex Number in Data	• Data sent from a function of this calculator (matrix, etc.) includes complex number data, but the corresponding function of the receiving calculator does not support data that includes complex numbers. Example: Attempting to send a matrix containing a complex number in an element to CFX-9850G.	• Send data that does not include complex numbers.
Can't Simplify	• Fraction simplification was attempted using the ►Simp function (page 2-19), but simplification could not be performed using the specified divisor. Example: Specifying a divisor of 3 to simplify the fraction 4/8.	• Specify a different divisor or execute ►Simp without specifying any divisor.

Message	Meaning	Countermeasure
Can't Solve! Adjust initial value or bounds. Then try again	• A Solve calculation could not obtain a solution within the specified range.	• Change the specified range. • Correct the input expression.
No Variable	① No variable specified within a graph function being used for Dynamic Graph. ② No variable within a Solve equation.	① Specify a variable for the graph function. ② Input a Solve equation that includes a variable.
Conversion ERROR	• Attempting to use the unit conversion command to convert between two units in different categories. • Executing a conversion calculation using the same command twice in a conversion expression.	• In a conversion expression, specify two different commands that are in the same category.
Com ERROR	• Problem with cable connection or parameter setting during program data communications.	• Check to make sure there is nothing wrong with the cable connection, and that parameters are configured correctly.
Transmit ERROR	• Problem with cable connection or parameter setting during data communications.	• Check to make sure there is nothing wrong with the cable connection, and that parameters are configured correctly.
Receive ERROR	• Problem with cable connection or parameter setting during data communications.	• Check to make sure there is nothing wrong with the cable connection, and that parameters are configured correctly.
Memory Full	• Memory of receiving unit became full during program data communications.	• Delete some data stored in the receiving unit and try again.
Invalid Data Size	• Attempting to send data of a size that is not supported by the receiving device. Example: Attempting to send a matrix with more than 256 lines from the fx-9750GII to an older model.	• Make sure the data being sent is of a size that is supported by the receiving device.
Invalid Data Number	• Attempting to send data with a data number that is not supported by the receiving device. Example: Attempting to send List 7 from the fx-9750GII to an older model that supports only up to List 6.	• Specify a data number supported by the receiving device when sending data.

Message	Meaning	Countermeasure
Time Out	• A Solve calculation or integration calculation was unable to satisfy convergence conditions.	• If you are performing a Solve calculation, try changing to the initial default estimated value. • If you are performing an integration calculation, try changing to a larger *tol* value.
Please Reconnect	• The connection was dropped for some reason while updating the operating system.	• Reconnect and try again.
Too Many Data	• The number of data items is too large.	• Delete unneeded data.
Invalid Name	• The file name you input includes invalid characters.	• Use the correct characters to input a valid file name.
Invalid Type	• An illegal data type is specified.	• Specify valid data.
Data ERROR	• A data error occurred.	• Check to make sure you are writing correct type of data and try again.

2. Input Ranges

Function	Input range for real number solutions	Internal digits	Precision	Notes
$\sin x$ $\cos x$ $\tan x$	(DEG) $\lvert x \rvert < 9 \times (10^9)°$ (RAD) $\lvert x \rvert < 5 \times 10^7 \pi$rad (GRA) $\lvert x \rvert < 1 \times 10^{10}$grad	15 digits	As a rule, precision is ±1 at the 10th digit.*	However, for $\tan x$: $\lvert x \rvert \neq 90(2n+1)$: DEG $\lvert x \rvert \neq \pi/2(2n+1)$: RAD $\lvert x \rvert \neq 100(2n+1)$: GRA
$\sin^{-1} x$ $\cos^{-1} x$	$\lvert x \rvert \leqq 1$	"	"	
$\tan^{-1} x$	$\lvert x \rvert < 1 \times 10^{100}$			
$\sinh x$ $\cosh x$	$\lvert x \rvert \leqq 230.9516564$	"	"	
$\tanh x$	$\lvert x \rvert < 1 \times 10^{100}$			
$\sinh^{-1} x$	$\lvert x \rvert < 1 \times 10^{100}$	"	"	
$\cosh^{-1} x$	$1 \leqq x < 1 \times 10^{100}$			
$\tanh^{-1} x$	$\lvert x \rvert < 1$			
$\log x$ $\ln x$	$1 \times 10^{-99} \leqq x < 1 \times 10^{100}$	"	"	• Complex numbers can be used as arguments.

Function	Input range for real number solutions	Internal digits	Precision	Notes
10^x	$-1 \times 10^{100} < x < 100$	15 digits	As a rule, precision is ±1 at the 10th digit.*	• Complex numbers can be used as arguments.
e^x	-1×10^{100} $< x \leqq 230.2585092$			
$\sqrt{x}$	$0 \leqq x < 1 \times 10^{100}$	"	"	• Complex numbers can be used as arguments.
x^2	$\lvert x\rvert < 1 \times 10^{50}$			
$1/x$	$\lvert x\rvert < 1 \times 10^{100}, x \neq 0$	"	"	• Complex numbers can be used as arguments.
$\sqrt[3]{x}$	$\lvert x\rvert < 1 \times 10^{100}$			
$x!$	$0 \leqq x \leqq 69$ (x is an integer)	"	"	
$n\mathrm{P}r$ $n\mathrm{C}r$	Result $< 1 \times 10^{100}$ n, r (n and r are integers) $0 \leqq r \leqq n$, $n < 1 \times 10^{10}$	"	"	
Pol (x, y)	$\sqrt{x^2 + y^2} < 1 \times 10^{100}$	"	"	
Rec (r, θ)	$\lvert r\rvert < 1 \times 10^{100}$ (DEG) $\lvert\theta\rvert < 9 \times (10^9)°$ (RAD) $\lvert\theta\rvert < 5 \times 10^7\pi$ rad (GRA) $\lvert\theta\rvert < 1 \times 10^{10}$grad	"	"	However, for tanθ : $\lvert\theta\rvert \neq 90(2n+1)$: DEG $\lvert\theta\rvert \neq \pi/2(2n+1)$: RAD $\lvert\theta\rvert \neq 100(2n+1)$: GRA
° ’ ”	$\lvert a\rvert, b, c < 1 \times 10^{100}$ $0 \leqq b, c$	"	"	
$\overleftarrow{\text{° ’ ”}}$	$\lvert x\rvert < 1 \times 10^{100}$ Sexagesimal display: $\lvert x\rvert < 1 \times 10^7$			
$\wedge(x^y)$	$x > 0$: $-1 \times 10^{100} < y\log x < 100$ $x = 0 : y > 0$ $x < 0 : y = n, \frac{m}{2n+1}$ (m, n are integers) However; $-1 \times 10^{100} < y \log \lvert x\rvert < 100$	"	"	• Complex numbers can be used as arguments.
$\sqrt[x]{y}$	$y > 0 : x \neq 0$ $-1 \times 10^{100} < \frac{1}{x} \log y < 100$ $y = 0 : x > 0$ $y < 0 : x = 2n+1, \frac{2n+1}{m}$ ($m \neq 0$; m, n are integers) However; $-1 \times 10^{100} < \frac{1}{x} \log \lvert y\rvert < 100$	"		• Complex numbers can be used as arguments.

Function	Input range for real number solutions	Internal digits	Precision	Notes
a^{b}/c	Total of integer, numerator and denominator must be within 10 digits (includes division marks).	15 digits	As a rule, precision is ±1 at the 10th digit.*	

* For a single calculation, calculation error is ±1 at the 10th digit. (In the case of exponential display, calculation error is ±1 at the last significant digit.) Errors are cumulative in the case of consecutive calculations, which can also cause them to become large. (This is also true of internal consecutive calculations that are performed in the case of ^(x^y), $^x\sqrt{y}$, $x!$, $^3\sqrt{x}$, nPr, nCr, etc.)

In the vicinity of a function's singular point and point of inflection, errors are cumulative and may become large.

Function	Input range
Binary, octal, decimal, hexadecimal calculation	Values fall within following ranges after conversion: DEC: –2147483648 ≦ x ≦ 2147483647 BIN: 1000000000000000 ≦ x ≦ 1111111111111111 (negative) 0 ≦ x ≦ 111111111111111 (0, positive) OCT: 20000000000 ≦ x ≦ 37777777777 (negative) 0 ≦ x ≦ 17777777777 (0, positive) HEX: 80000000 ≦ x ≦ FFFFFFFF (negative) 0 ≦ x ≦ 7FFFFFFF (0, positive)

3. Specifications

Variables: 28

Calculation range:

±1 × 10^{-99} to ±9.999999999 × 10^{99} and 0. Internal operations use 15-digit mantissa.

Exponential display range: Norm 1: $10^{-2} > |x|$, $|x| \geqq 10^{10}$
Norm 2: $10^{-9} > |x|$, $|x| \geqq 10^{10}$

Program capacity: 62,000 bytes (max.)

Power supply: Four AAA-size batteries (LR03 (AM4))

Power consumption: 0.35 W

Approximate battery life

300 hours (continuous display of main menu)

230 hours continuous operation (5 minutes calculation, 55 minutes display)

1 year (unused with power off)

- Any of the following can shorten battery life.
  - Sequential program calculation execution
  - Certain battery types

Auto power off:

Power is automatically turned off approximately 10 minutes or 60 minutes after last operation.

Ambient temperature range: 0°C to 40°C (32°F to 104°F)

Dimensions: 21.3 mm (H) × 87.5 mm (W) × 180.5 mm (D)
7/8" (H) × 3 1/2" (W) × 7 1/8" (D)

Approximate weight: Approx. 205 g (7.2 oz) (including batteries)

Data Communications

3-pin serial port

Method: Start-stop (asynchronous), half-duplex

Transmission speed (BPS):

115200 bits/second (normal)

9600 bits/second (When connected to CFX-9850G series or fx-7400G series calculator; Send/Receive commands)

38400 bits/second (Send38k/Receive38k commands)

<115200 bits/second>

Parity: EVEN

Bit length: 8 bits

Stop bit:

Send: 1 bit

Receive: 1 bit

Includes parity (None) 1-bit

X ON/X OFF Control: None

<9600, 38400 bits/second>

Parity: None

Bit length: 8 bits

Stop bit:

Send: 3 bits

Receive: 2 bits

Includes parity (None) 1-bit

X ON/X OFF Control: None

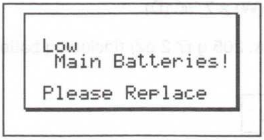
USB port

In accordance with USB 1.1 standards

4. Power Supply

This calculator is powered by four AAA-size (LR03 (AM4)) batteries.

If the following message appears on the display, immediately turn off the calculator and replace the batteries as instructed.



```
Low
 Main Batteries!

Please Replace
```

If you try to continue using the calculator, it will automatically turn off in order to protect memory contents. You will not be able to turn power back on until you replace batteries.

Be sure to replace the batteries at least once every one year, no matter how much you use the calculator during that time.

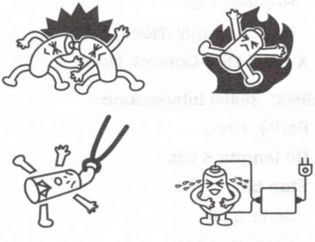
The batteries that come with this calculator discharge slightly during shipment and storage. Because of this, they may require replacement sooner than the normal expected battery life.

■ Replacing Batteries

Precautions:

Incorrectly using batteries can cause them to burst or leak, possibly damaging the interior of the calculator. Note the following precautions:

- Be sure that the positive (+) and negative (–) poles of each battery are facing in the proper directions.
- Never mix batteries of different types.
- Never mix old batteries and new ones.
- Never leave dead batteries in the battery compartment.
- Remove the batteries if you do not plan to use the calculator for long periods.
- Never try to recharge the batteries supplied with the calculator.
- Do not expose batteries to direct heat, let them become shorted, or try to take them apart.



(Should a battery leak, clean out the battery compartment of the calculator immediately, taking care to avoid letting the battery fluid come into direct contact with your skin.)

> Keep batteries out of the reach of small children. If swallowed, consult with a physician immediately.

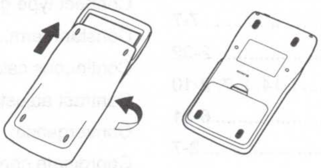
• To replace the batteries

- Never turn on the calculator while the batteries are removed or not loaded correctly. Doing so can cause memory data to be deleted and malfunction of the calculator. If mishandling of batteries causes such problems, correctly load batteries and then perform the restart operation to resume normal operation.
- Be sure to replace all four batteries with new ones.

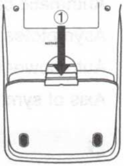
1. Press SHIFT AC/ON (OFF) to turn off the calculator.

   Warning!

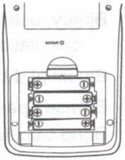
   - Be sure to turn the calculator off before replacing batteries. Replacing batteries with power on will cause data in memory to be deleted.
2. Making sure that you do not accidently press the AC/ON key, slide the case onto the calculator and then turn it over.



3. Remove the battery cover from the calculator by pulling with your finger at the point marked ①.



4. Remove the four old batteries.
5. Load a new set of four batteries, making sure that their positive (+) and negative (–) ends are facing in the proper directions.
6. Replace the battery cover.
7. Turn the calculator front side up and slide off its case. Next, press AC/ON to turn on power.



- If the figures on the display appear too light and hard to see after you turn on power, adjust the contrast.

■ About the Auto Power Off Function

Calculator power turns off automatically if you do not perform any operation within the Auto Power Off trigger time you specify. You can specify either 10 minutes or 60 minutes as the trigger time (see “Power Properties” on page 10-1). To restore power, press AC/ON.

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Canadian Regulatory Information
Information concernant la Réglementation Canadienne

This Class B digital apparatus complies with Canadian ICES-003.
Cet appareil numérique de la classe B est conforme à la norme NMB-003 du Canada.

CASIO®

CASIO COMPUTER CO., LTD.

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One or more of the following patents may be used in the product.
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